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Sustainable Energy Innovation (SEI) within Private Finance Initiative (PFI) Projects

A thesis submitted in partial fulfilment of the requirements for the degree of Doctor of Philosophy at University College London (UCL)

2012

In Loving Memory of My Inspirational Father

Mustafa H. Badi

(1941-2004)

His words of encouragement in the pursuit of knowledge are never forgotten.

Acknowledgments

I wish to express my heartfelt appreciation to several people who have contributed in many ways to the completion of this study. I would like to thank my supervisors Dr Stephen Pryke and Professor Peter Morris of the Bartlett School of Construction and Project Management (UCL) for their continued encouragement, support and guidance. I would also like to thank the Bartlett Departmental Scholarship for the financial support that made this research possible.

I would also like to thank my examiners, Dr Taha Elhag of the Bartlett School of Construction and Project Management (UCL) and Dr Tim Brady of the CENTRIM Centre for Research in Innovation Management (University of Brighton) for the thorough discussion and feedback that made my viva such an enjoyable experience.

I am grateful to all the research interviewees who generously gave up their time to participate in this study. You made this research worthwhile!

I am also indebted to my beloved Mum and sisters, Rehab, Maysoon and Nora for their love and prayers and for always believing in me.

Finally, I am most indebted to my Husband Kamal and our beautiful children, Mustafa, Shahd, Danah and Mohamed for their unconditional love and support and for defining my sense of purpose in life and the value of this thesis. Love you so much!

Sulafa Badi
March 2012

Abstract

The purpose of this study is to examine the capacity of the Private Finance Initiative (PFI) project delivery model to support the implementation of Sustainable Energy Innovation (SEI) within the context of the UK government's Building Schools for the Future (BSF) programme. The study attends to a significant gap in knowledge as there is a lack of conceptual and empirical work on managing innovative processes for sustainable energy in PFI projects. Adopting Complex Product Systems (CoPS) Innovation Management Theory, the BSF PFI project is conceptualised as a CoPS supply network where success in innovation largely depends on the interactive relationships among multiple project participants (Hobday, 1998, 2000; Hobday et al., 2000; Gann and Salter, 2000). A conceptual framework is developed based on three determinants of CoPS innovation, particularly: (1) clarity of the requirement, (2) communication and collaboration and (3) contractual incentives. Taking such a system-oriented perspective is considered important for SEI due to the increasing levels of functional dependency and component complexity associated with environmental innovations. Thus, effective interaction among producers, clients and users is seen to be critical for their successful development (Rohracher, 2001; Intrachooto and Horayangkura, 2007).

Following a four-case qualitative research methodology, the empirical findings point to the significance of the three determinants of CoPS innovation in shaping the environment in which private sector producers operate and innovate in BSF PFI projects. However, while the qualitative nature of the chosen research methodology limits the ability to generalise, the case study findings provide empirical evidence to the limited capacity of the PFI delivery model to support SEI based on the key determinants postulated in CoPS Innovation Management Theory. The research establishes that the capacity of the BSF PFI project delivery model to support SEI is weakened by: the limited clarity of the sustainable energy requirement particularly in relation to its specificity and achievability; ineffective multidisciplinary communication and collaboration within the integrated ProjectCo due to restricting internal contractual relationships and the misalignment of Design-Construction-Operation sustainability objectives; and ineffective Client/User-Producer communication and collaboration brought in by the restricted nature of BSF engagement processes as well as the misalignment of Client/User-Producer sustainability objectives. Contractual incentives were found to support SEI, albeit by fear of financial penalties through risk allocation, rather than pursuit of reward for innovation.

The study concluded that the BSF PFI project delivery model, as a procurement policy, may not adequately appreciate the system dynamics needed for successful SEI. Indeed, the study underlined a number of problematic issues, or 'hotspots' (Hansen and Rush, 1998; Hobday and Rush, 1999), weakening the key determinants of CoPS innovation success in BSF PFI projects. Recommendations were developed to rectify the identified problematic issues. Future research directions were also suggested.

Key words:

The Private Finance Initiative (PFI), Sustainable Energy Innovation (SEI), Complex Product Systems (CoPS) Innovation Management Theory, Clarity of Requirement, Communication and Collaboration, Contractual Incentives, Risk Allocation, Reward Sharing Mechanisms.

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List of Abbreviations, Acronyms and Initialisations

ADB	Asian Development Bank
BB	Building Bulletin
BBCap	Balfour Beatty Capital
BCC	Bristol City Council
BEC	Brislington Enterprise College
BLT	Build, Lease and Transfer
BMS	Building Management System
BOO	Build, Own and Operate
BOT	Build, Operate and Transfer
BRE	Building Research Establishment
BREEAM	Building Research Establishment's Environmental Assessment Method
BSF	Building Schools for the Future
BSFI	Building Schools for the Future Investments
BWS	Big Wood School
CABE	Commission for Architecture and the Built Environment
CBI	Confederation of British Industry
CGOEMC	Colorado Governor's Office of Energy Management and Conservation
CHP	Combined Heat and Power
CIC	Construction Industry Council
CoPS	Complex Product System
CO_2	Carbon Dioxide
CP	Contractor Proposal
CRC	Carbon Reduction Commitment
DBFO	Design, Build, Finance and Operate
DCSF	Department for Children, Schools and Families
DEFRA	Department for Environment, Food and Rural Affairs
DETR	Department of Environment Transport and the Regions
DfE	Department for Education
DfES	Department for Education and Skills

DQI	Design Quality Indicator
DTI	Department of Trade and Industry
D&B	Design and Build
EPA	The United States Environmental Protection Agency
ESCOs	Energy Supply Companies
FCCC	Framework Convention on Climate Change
FBC	Final Business Case
FC	Financial Close
FM	Facility Management
GDP	Gross Domestic Product
HGS	Highbury Grove School
HVAC	Heating, Ventilation, and Air Conditioning Technologies
ICT	Information and Communication Technology
InvestCo	Investment Company
IPCC	Intergovernmental Panel on Climate Change
ITCD	Invitation to Continue Dialogue
ITN	Invitation to Negotiate
ITPD	Invitation to Participate in Dialogue
ITSFB	Invitation to Submit Final Bid
JP	Joint Procurement
LA	Local Authority
LBI	London Borough of Islington
LCC	Leicester City Council
LEP	Local Education Partnership
LMEC	Leicester Miller Education Company
LTS	Large Technical Systems
MOI	Memorandum of Understanding
M&E	Mechanical and Electrical
NAO	National Audit Office
NCC	Nottingham City Council
NDPB	Non-departmental Public Body
PB	Preferred Bidder
PFI	Private Finance Initiative
PLC	Public Limited Company
PSC	Public Sector Comparator
PUK	Partnerships UK

OBC	Outline Business Case
OECD	Organisation for Economic Co-operation and Development
OGC	Office of Government Commerce
OJEU	Official Journal of the European Union
O&M	Operate and Maintain
PFI	Private Finance Initiative
PFPE	Private Finance Panel Executive
PfS	Partnership for Schools
PPP	Public Private Partnership
PQQ	Pre-qualification Questionnaire
ProjectCo	Project Company
PVs	Photovoltaic panels
RCF	Reading Construction Forum
RIBA	Royal Institute of British Architects
PID	Project Initiation Document
PMBOK	Project Management Body of Knowledge
PSP	Private Sector Partner
PWC	PriceWaterhouseCoopers
REEP	Renewable Energy and Efficiency Partnership
R&D	Research and Development
SBC	Strategic Business Case
SDAP	Sustainable Development Action Plan
SDC	Sustainable Development Commission
SEI	Sustainable Energy Innovation
SET	School Engagement Team
SfC	Strategy for Change
SHA	Shareholder Agreement
SPA	Strategic Partnering Agreement
SPTF	Sustainable Procurement Task Force
SPV	Special Purpose Vehicle
SVC	Soar Valley College
TTF	Treasury Task Force
UNIDO	United Nations Industrial Development Organization
VfM	Value-for-Money
WCED	The United Nations World Commission on Environment and Development
WLC	Whole Life Cost

Chapter 1: Introduction

1.1 Introduction

This research sets out to examine the capacity of the Private Finance Initiative (PFI) project delivery model to support the implementation of Sustainable Energy Innovation (SEI) within the context of the UK government's Building Schools for the Future (BSF) programme. The aim of this Chapter is to explore the subject domain and narrow it down to describe the specific problem area and the research questions of this study. The Chapter begins with an introduction to the research context. The need for technological innovation to meet global calls for sustainable development and sustainable energy will be highlighted. Energy consumption in UK school buildings will be explored and national policies to reduce energy consumption in buildings, with a particular focus on school buildings will be outlined. The Chapter then turns to PFI as a delivery model for UK school buildings. The objectives behind its adoption as the preferred delivery model for new-build schools within the UK government's controversial building programme, BSF, will be explained. The fifth section will explore the research issue, questions, and objectives. The value of the research study is then highlighted, focusing on the importance of the research issue, gaps in the literature, and potential benefits of the research outcome. The study's scope is explained and the structure of the report outlined.

1.2 Climate Change and Sustainable Energy Innovation (SEI)

There are growing calls around the globe for technological innovation to meet the challenges of Climate Change and CO_2 emission reductions (Cabinet Office, 2002). In fact, technological innovation is said to be a 'must' for sustainable development (Mulder, 2007; OECD, 2003; Stern, 2006; DEFRA, 2007; DTI, 2007). The urgent need for sustainable development stems from increasing concerns about Climate Change and the effect of emissions of greenhouse gases on the gradual increase in

World temperatures over time, now commonly known as Global Warming. The 'greenhouse effect' means that greenhouse gases such as water vapour (H_2O), carbon dioxide (CO_2), methane, nitrous oxide, and fluorocarbons insulate the Earth by absorbing heat from the Earth's surface and reflecting it back into the atmosphere, acting in a similar way to a thermal blanket (Houghton, 2005). Although associated in recent times with pollution and Climate Change, the greenhouse effect is essential for the continuity of the Earth's climate (Karl and Trenberth, 2003). However, since the beginning of the Industrial Revolution, the burning of fossil fuel meant that the greenhouse effect changed from simply protecting the Earth's climate to causing an actual increase in World temperatures (Martinez, 2005; Houghton, 2005). The gaseous culprit is the seemingly 'innocuous' CO_2; although harmless in the right atmospheric proportions, it is nevertheless a very powerful insulator and heat reflector (Houghton, 2005). Since 1750, the concentration of CO_2 has increased by over 30% and is now at a higher level than it has been for thousands of years (Martinez, 2005; EPA, 2007).

Image 1.1: The Melting of the Arctic Ice Cap
Courtesy of Telegraph.co.uk (2010)

The scientific evidence on Global Warming dates as far back as the second half of the 19th Century and the work of physicist John Tyndall and chemist Svente Arrhenius. It was particularly accelerated in the past 20 years through the Intergovernmental Panel on Climate Change (IPCC), established in 1988 by the United Nations Environment Program and the World Meteorological Organisation to review scientific and technical research on Climate Change, and to consider possible options for adaptation and mitigation (Martinez, 2005). In 2001, the IPCC established that the average global temperature had increased one Fahrenheit degree over the last Century and would rise by another 2.5 to 10.4 degrees Fahrenheit by the year 2100 (IPCC, 2001). It also determined that this temperature increase has been primarily the result of human activities that have released greenhouse gases into the atmosphere. While there are some sceptics concerning the theory of Global Warming (e.g. Lindzen, 2004; Carlisle, 1998), the scientific consensus is that Global Warming is anthropogenic (Oreskes, 2004) and is set on a worrying path (Stern, 2006). The main sources globally are electricity generation, land-use changes (particularly deforestation), agriculture and transport (Stern, 2006). The fastest growing sources are transport and electricity (Stern, 2006).

The increase in Global Warming will have severe implications for human communities (Houghton, 2005). The expansion of ocean water as it warms will raise the global sea level (IPCC, 2007a). This will cause flooding of low-lying regions, such as the Everglades region of Florida, Bangladesh, Southern China, islands in the Indian and Pacific oceans, as well as many other regions in the World (Houghton, 2005; Stern, 2006). Besides widespread flooding, there will also be an increase in extreme weather events such as unusually high temperatures and the increase in average precipitation across the globe (IPCC, 2007a). The hydrological cycle will become more intense, leading to floods in some areas and droughts in others – probably the two most damaging of the World's disasters (Houghton, 2005). Of less certainty, but no less damaging, is the potential meltdown of the Arctic Ice Cap (Stroeve, 2007; IPCC, 2007b). If the temperature in Greenland were to rise above 3°C, then the ice cap meltdown would begin, irreversibly. Over the course of 1000 years, complete meltdown would add around 7 metres to the World's sea level (Gregory *et al.*, 2004), with extremely damaging results for mankind and the ecosystem (Houghton, 2005). Global emissions of CO_2 to the atmosphere from fossil fuel burning are approaching 7 billion tonnes of CO_2 per annum and are rising rapidly (Houghton, 2005; Stern, 2006). In fact, if the World community continues with 'business as usual', energy-related emissions are forecasted to grow by over 2% per year over the next 30 years (Stern, 2006). Therefore, there are global calls for emissions during the 21st Century to be reduced to a fraction of their present levels before the Century's end in order to stabilise CO_2 concentrations (Houghton, 2005; Stern, 2006).

Indeed, there is now a widespread acceptance of the human responsibility for most of the Global Warming and the awareness of the impact of sustainable development is growing around the World (Egbu, 2006). The United Nations World Commission on Environment and Development (WCED) presented in 1987 their report *Our Common Future* (also known as *The Brundtland Report*). The report placed sustainable development within the economic and political context of international development. It also formulated the most common definition for sustainable development:

> Sustainable development is development, which meets the needs of the present without compromising the ability of future generations to meet their own needs (Brundtland Report, 1987, p. 43).

The report also outlined that sustainable development fundamentally comprises the three broad themes of social, environmental, and economic accountability, often known as the 'Triple Bottom Line' shown in Figure 1.1.

Figure 1.1: The Three Themes of Sustainable Development

Source: Developed for this research study based on Khalfan (2002)

A major element of environmental sustainability is sustainable energy. In fact, sustainable energy is often regarded as the central theme to realising the goals of sustainable development (Dincer and Rosen, 1999; Rogner *et al.*, 2001). Sustainable energy is defined as:

> The dynamic harmony between the equitable availability of energy-intensive goods and services to all people and the preservation of the Earth for future generations … the solution will lie in finding sustainable energy sources and more efficient means of converting and utilizing energy (Tester *et al.*, 2005, p. xix).

Indeed, energy efficiency and renewable energy are considered to be the 'twin pillars' of sustainable energy and both should be earnestly developed if CO_2 emissions are to be stabilised and reduced (Prindle *et al.*, 2007). Energy efficiency is essential to slow the growth in energy demand, while renewable energy is needed to reduce the carbon content of energy sources (Prindle *et al.*, 2007). One of the most significant developments for sustainable energy was in the 1992 UN Earth Summit in Rio de Janeiro where 178 countries signed the Framework Convention on Climate Change (FCCC). By doing so, they agreed to 'take preventative measures to anticipate, prevent, or minimise the causes of Climate Change and mitigate its adverse effects' (Article 3). One important outcome from the Rio Conference was *Agenda 21,* a comprehensive plan of action to be taken globally, nationally, and locally by organisations of the United Nations System, governments, and Major Groups in every area in which humans impact on the environment, in order to achieve sustainable development.

Further progress in the process of reducing greenhouse gases emissions took place in the form of the Kyoto Protocol in the year 2005. The Kyoto Protocol is an international agreement linked to the United Nations Framework Convention on Climate Change, in which 38 countries committed to reducing their greenhouse gases emissions. The binding targets are an average of 5% against 1990 levels over the five-year period 2008–2012. The Protocol represented a major development from the Convention because while the Convention encouraged industrialised countries to stabilise greenhouse gases emissions the Protocol legally committed them to do so. The Protocol also identified developed countries as principally responsible for the current high levels of greenhouse gases emissions in the atmosphere through their extensive industrial activity for more than 150 years. Therefore, developed nations are placed with a heavier burden under the principle of 'common but differentiated responsibilities'. National targets range from 8% reductions for the European Union, 7% for the USA, 6% for Japan, 0% for Russia, and permitted increases of 8% for Australia and 10% for Iceland.

In the UK, and in order to address Climate Change challenges, ambitious objectives and strategies for sustainable development were developed. The year 1999 saw the introduction of the UK National Sustainable Development Strategy (HM Government, 1999). In the strategy, sustainable development is sought to be integrated at all levels of government policy and administration with government departments, regional development agencies, and local authorities among others expected to contribute to its achievement. Further initiatives were introduced in 2003 signalling the government's commitment to using procurement as a lever for sustainable development. The Department for Environment, Food and Rural Affairs (DEFRA) and the Office of Government

Commerce (OGC) announced at the time that all new central government contracts must apply minimum environmental standards when purchasing certain types of product. DEFRA also managed the Framework for Sustainable Development on the government Estate and negotiated targets for environmental performance across all departments, including a 10% reduction in road transport emissions by 2006. *The Energy White Paper* (DTI, 2003c) was also published, describing policies to support a government target of 60% reduction in CO_2 emissions by 2050.

Further developments took place in the form of the Stern Review, published in October 2006, drawing attention to the economic consequences of Climate Change and proposing ways to combat those effects (Stern, 2006). The report highlighted the role of government in providing a clear policy framework to guide effective adaptation by individuals and firms, particularly in the area of land-use planning and performance standards (Stern, 2006). Another development was DEFRA's report '*Procuring the Future*: *Sustainable Procurement National Action Plan'* (DEFRA, 2006). The report recommended the government use its public buying-power to support social, economic, and environmental sustainability. In its forward, Sir Neville Simms, Chairman of the Sustainable Procurement Task Force (SPTF), drew attention to the urgent need for sustainable development when he said:

> Future generations will neither excuse us nor forgive us for ignoring the signals that we can see today. But if the latest sustainability strategy is driven forward with determination and the government's huge spending power is harnessed … and if the first steps are taken now, right now, future generations will have much to thank our leaders for (DEFRA, 2006, p. 2).

Additional summary reports were produced by the IPCC setting out the effects of Climate Change and the policy initiatives that are needed to address those effects. In its summary *Climate Change 2007: Impacts, Adaptation and Vulnerability*, the IPCC signalled the role of development-planning and infrastructure design in combating the adverse effects of Climate Change. As the IPCC argued:

> One way of increasing adaptive capacity is by introducing the consideration of Climate Change impacts in development planning, for example by … including adaptation measures in land-use planning and infrastructure design (IPCC, 2007, p. 20).

Moreover, the government published its *Draft Climate Change Bill* in 2007, which sets to incorporate in statute the government's previously announced target of 60% reduction of UK CO_2 emissions by 2050 compared to a 1990 baseline. The year 2008 saw the introduction of the government's *Climate Change Act 2008* which became law on 26 November 2008, forming the World's first long-term legally binding framework to tackle the dangers of Climate Change.

Among the key strategies to achieve global CO_2 emission reductions is technological innovation (Cabinet Office, 2002). Indeed, technological innovation is considered a requisite for sustainable development (Mulder, 2007; EPA, 2002). The OECD (2003) argues that new technologies will play a major role in supporting the crucial aim of the UN Convention on Climate Change: 'stabilising atmospheric concentrations of greenhouse gases', ultimately resulting in near elimination of CO_2 emissions. According to OECD (2003):

> Without radical changes in life styles, only a massive deployment of carbon-free (or close to carbon-free) energy technologies can power the World economy and satisfy growing energy needs, especially of the developing World, while making stabilization sustainable over the long term (OECD, 2003, p. 7).

Indeed, several government reports highlighted the importance of innovation in meeting the pressing need for sustainable energy and CO_2 emission reduction (Stern, 2006; DEFRA, 2007; Thalmann, 2007; DTI, 2007). Innovation is expected to play a major role in dealing with the issue because, as Thalmann (2007) argues, 'technological change supports all the hopes for painless reduction in greenhouse gases emissions' (Thalmann, 2007, in Kern, 2008, p. 2). The Stern Review on the economics of Climate Change also stresses the need for innovation and discovery (Stern, 2006). It emphasises that 'policy to support innovation and the deployment of low carbon technologies will be a key response to mitigating Climate Change' (DTI 2007, p. 216). However, a number of research studies have identified that such innovations are still in their 'embryonic' stages (e.g. Kelly, 2008). Emphasising that innovation inherently involves novel activities and knowledge, Rennings (1998) calls for further research in order to 'improve our understanding of innovation processes towards sustainability in their different dimensions, complex feedback mechanisms and interrelations' (p. 2).

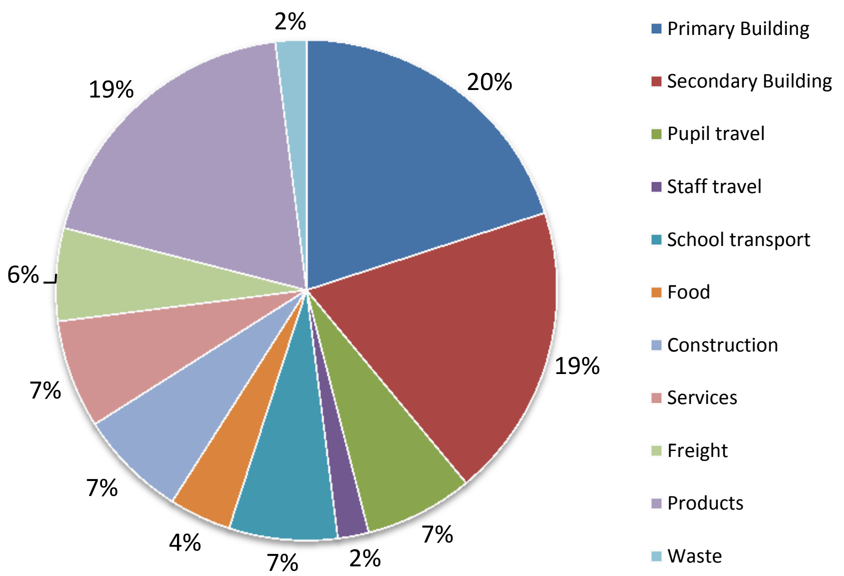
The next section will outline energy consumption in UK school buildings and explore national policies to reduce energy consumption in buildings, with a particular focus on school buildings.

1.3 The Need for Sustainable Energy in UK School Buildings

The UK, along with all other developed countries, is totally dependent on energy for its development and prosperity. The main physical consumers of energy in the UK are Buildings (45%), Transportation (33%), and Industry (21%) (Action Energy, 2002). Buildings account for the largest overall proportion of UK energy consumption and thus reducing their energy consumption should be high on the list of priorities when it comes to reducing the overall UK energy consumption (Action Energy, 2002). Of the energy consumed in buildings, 64% is used by housing, 9% by industrial buildings, and 27% by office buildings (Action Energy, 2002).

School buildings are responsible for about 2% of greenhouse gases emissions in the UK. This is the equivalent to 15% of the national public sector emissions (DCSF, 2010). The Sustainable Development Commission (SDC) estimates that school buildings in England emit 9.4 million tonnes of CO_2 each year. Energy use in school buildings represents 37% of this, a total of 3.5 million tonnes of CO_2 each year (DCSF, 2010). Figure 1.2 shows a detailed sector breakdown of schools' carbon footprint.

Figure 1.2: Percentage CO_2 Emission in School Buildings



Source: DCSF (2010)

Certainly, school buildings are particularly important in the effort to reduce CO_2 emissions and combat Climate Change, given their long life span (DCSF, 2007b). There is a strong call for school buildings to become more sustainable by meeting the teaching needs of today's population whilst incorporating the flexibility needed to accommodate future development (DCSF, 2007b). The vital role of schools in educating the next generation about Climate Change was emphasised in 2006 by Alan Johnson, then Secretary of State for Education and Skills, when he said:

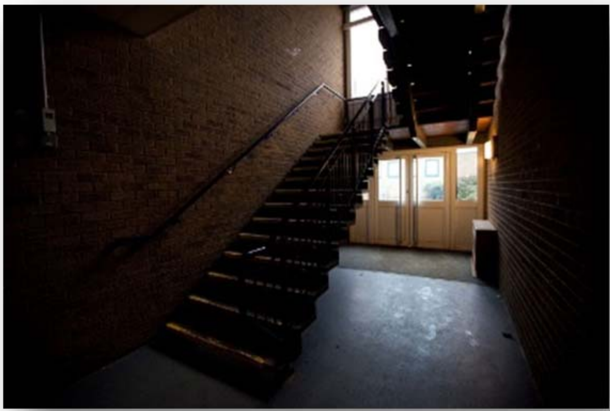


Image 1.2: Interior of a Secondary School in the East Midlands
Courtesy of Building (2010)

Image 1.3: Interior of the Michael Tippett School, Lambeth BSF, opened in February 2008
Courtesy of Building (2010)

> Schools are there to give children the knowledge and skills they need to become active members of society. Many children are rightly worried about Climate Change, global poverty and the impact of our lifestyles. Schools can demonstrate ways of living that are models of good practice for children and their communities. They can build sustainable development into the learning experience of every child to encourage innovation and improvement (DCSF, 2007b, p. 5).

In order to address the need for sustainable development in school buildings, the Department for Children, Schools, and Families (DCSF) developed challenging targets for sustainable school buildings that support the wider government policies on low energy/carbon buildings (DCSF, 2010). The Department launched its first Sustainable Development Action Plan (SDAP) in September 2003. The year 2007 witnessed an important development when the DCSF published its report *The Children's Plan*. The report outlined the UK government's 10-year strategy to 'make [England] the best place in the World for children and young people to grow up' (DCSF, 2007, p. 1). In the report, the DCSF announced that £110 million would be allocated for sustainable school buildings. This takes the form of an additional investment of £50/m^2 for new schools to achieve a 60% reduction in CO_2 emissions, compared to a school building that is designed to the energy efficiency standards set out in the 2002 Building Regulations. The report also established an unequivocal commitment to 'World-class buildings' and set the ambitious target that all new-build schools should be zero-carbon by 2016. Appendix A outlines the prevailing government policies and environmental regulations for school buildings and how they relate to sustainability. Although education policy is complex and continuously evolving, the government messages about sustainability are consistent (Wilkinson, 2008). As Wilkinson (2008) highlights, the fact that the UK school estate accounts for 15% of the public sector's CO_2 emissions is a strong driver for immediate action.

1.4 The Private Finance Initiative (PFI) in UK School Buildings

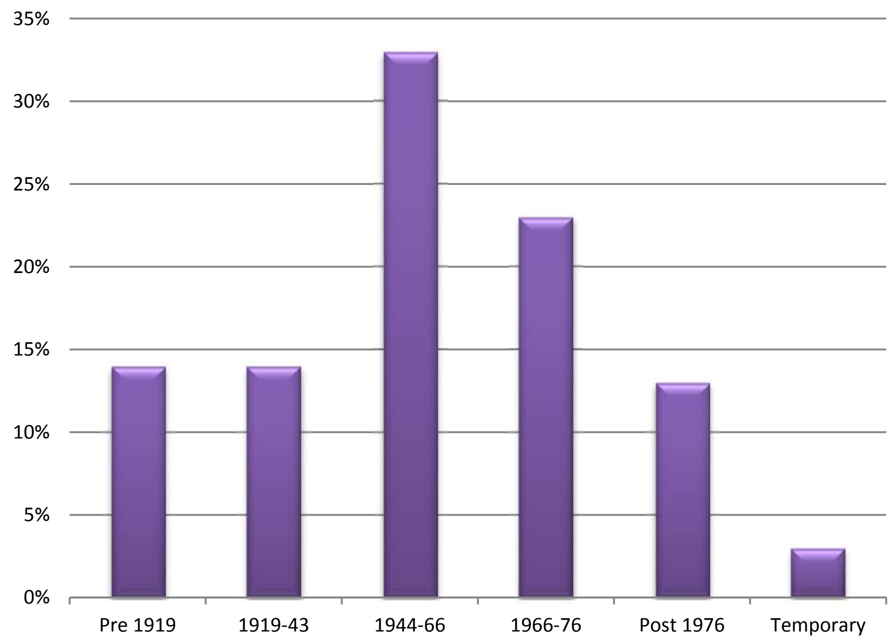
There are about 24,000 state schools in England, 3,500 of which are secondary schools with most of the rest being primary schools (Wilkinson, 2002). These are owned and managed by England's 150 local authorities. School facilities largely vary in relation to their building's condition and suitability for teaching the curriculum. In 2002 around 14% of existing school buildings were built in the last 25 years, but about 30% were more than 50 years old. Combined with low levels of investment in previous decades, the age of many school buildings signalled a significant need for investment. The age divide is illustrated in Figure 1.3 (Page 11).

The Labour government assumed power in 1997 and quickly recognised that capital investment is vital to realising the World-class standard of education that they aspired to deliver. The government sought earnestly to turn into reality their commitment in opposition to make 'education, education and education' their three main priorities (Barber, 2001). Gordon Brown, then Chancellor of the Exchequer, said at the time:

> Economic success tomorrow will depend on investing in our schools today. But at the present rate of progress, many of our children will be educated for the 21st Century in classrooms built in the 19th Century … If our schools are to educate for

the needs of the 21st Century economy, they must themselves become schools that are fit to learn in and equipped for the 21st Century (Gordon Brown, Chancellor of the Exchequer, 1997, In: House of Commons, 2007, p. 10).

Figure 1.3: Age of School Buildings in England



Source: Wilkinson (2002)

To meet these objectives, the government has demonstrated, with distinct enthusiasm, its desire to utilise the Private Finance Initiative (PFI) as a source of finance for education. Traditionally, schools in the UK have been entitled to spend the bulk of their annual budgets as they see fit. Most capital resources were allocated by formulae and the remainder through a government-sponsored bidding process. Examination of the bidding process, as Matthew (2004) argues, reveals procedural complexity as well as the DCSF reducing the percentage of funds allocated for bidding. A conclusion reached is that through decreasing the options to bid, PFI became a more attractive alternative (Ball *et al.*, 2000; Matthew, 2004).

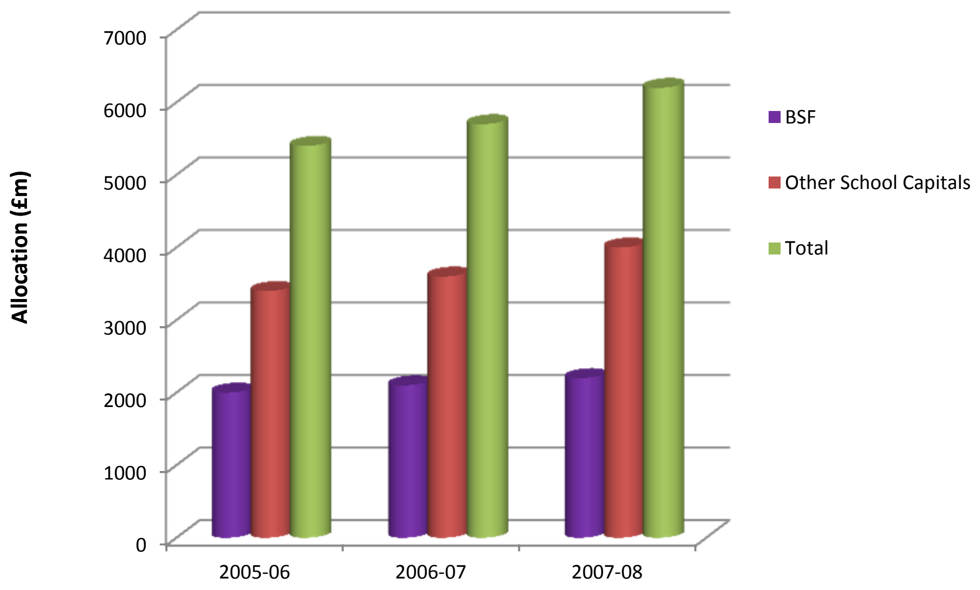
The PFI project delivery model is a specific type of Public Private Partnership (PPP). In PFI projects, a consortium of private sector firms assumes the responsibility of designing, constructing, financing, and operating an infrastructure facility. In addition, the PFI consortium of firms is contracted to provide the public services on a long-term contractual basis (up to 30 years) with the relevant government body. It has been argued that the introduction of PFI has many benefits. These include control of public sector expenditure to curb inflation, overcoming the scarcity of public funds, and control over the Public Sector Borrowing Requirement as PFI contracts can be treated as 'off balance sheet' (Butler and Stewart, 1996; Broadbent and Laughlin, 1998; McCabe *et al.*, 2001). The £11.5m redevelopment of Colfox School in Bridport, Dorset, was the first PFI public sector school to be funded through the private sector (Matthew, 2004). In 1996/7 only 1% of schools' funding was assigned to PFI projects, but by 2001, 25 new PFI schools had been opened, and by 2003 approximately 500 schools were engaged in 142 PFI projects (DfES, 2004d).

The attraction of PFI projects was further emphasised in 2004 through the Department for Education and Skills (DfES) launch of their most comprehensive capital programme: 'Building Schools for the Future' (BSF). The aim of BSF was to rebuild or renew every secondary school in England over a period of approximately 10–15 years, subject to future public spending decisions. The goal of the programme was to promote reform in the organisation of schooling, teaching, and learning, and to drive transformational educational change (DfES, 2005a). At the heart of these goals, BSF attempted to introduce three key changes. First, annual bidding rounds for strategic capital investment were removed and funding was allocated to local authorities by wave, based on need. Second, local authorities were required to develop an innovative long-term educational vision, which considers the whole estate and extends school activities and related services such as healthcare and social care into the local community. Third, BSF was based on a strong drive to Value-for-Money (VfM) and procurement efficiency. This was achieved using a PPP model called the Local Education Partnership (LEP). The LEP was a joint venture between a suitable Private Sector Partner, the Local Authority, and Partnership for Schools (PfS), the public body responsible for managing the programme (DfES, 2004c). All local authorities taking part in BSF were expected to adopt the LEP model unless they could demonstrate better VfM and a more effective method of delivering BSF investment. The funding allocated to individual projects was based on enabling up to 50% of the gross floor area of a Local Authority's school estate to be new-build, 35% major refurbishment, and 15% minor refurbishment (DfES, 2005a). The 50% new-build element was delivered through PFI contracts as it was found to represent best value to the public sector (DfES, 2005a).

The BSF programme started in 2003/04 with a series of pathfinder projects. In 2005/06, BSF accounted for roughly 40% of the DCSF capital investment, £2.2 billion out of a total of £5.1 billion. Of the £2.2 billion for BSF, £1.2 billion (55.5%) was covered by PFI credits. BSF was the largest of the

DCSF programmes and represented a third of the total capital allocation as shown in Figure 1.4 below.

Figure 1.4: School Capital Allocation 2005/08



Source: DfES (2005a)

The BSF programme, however, came to an abrupt halt shortly after the Coalition government assumed power in May 2010. The new government announced in July 2010 its plans to withdraw funding for all BSF projects that were yet to reach financial close, a total of 715 schools (Glenigan, 2010). The BSF programme was criticised for being too bureaucratic, wasteful, and delivering low quality schools. The legitimacy of the Coalition government’s decision to cancel the BSF programme is a subject of legal action taken by a number of local authorities, including Nottingham, Luton, and London’s Waltham Forest councils, at the time of writing this thesis. Nevertheless, since its initiation in 2004 a total of 123 schools had been completely rebuilt or substantially refurbished under BSF, of which 47 were PFI. A further 85 PFI school projects were unaffected by the cancellation of the programme and plans for their redevelopment continued (DfE, 2010). In total, PFI was the delivery model for 132 new-build BSF school projects.

1.5 Defining the Research Issue, Questions, and Objectives

The previous sections outlined the government's challenging objectives for sustainable school buildings, culminating in the most ambitious target of zero-carbon schools by 2016. During its years, the need for BSF to act as a vehicle for change and deliver the government's sustainable energy objectives was vital. This was signalled in the DEFRA (2006) *Procuring the Future: Sustainable Procurement National Action Plan* report, identifying BSF schools as a priority area and recommending that the DCSF and HM Treasury work together to ensure that new-build school developments were meeting high sustainability standards (DEFRA, 2006). The issue was also highlighted by several government officials:

> Sustainability must be embedded in BSF: buildings and their long-term, whole-life maintenance must demonstrate sustainability, from recycling facilities through to energy efficiency (PfS, 2007, p. 12).

> If the government is to meet a target of at least 60% reduction against the 1990 baseline, and if it intends to set an example by the way in which it looks after the public sector building stock, it clearly has to address the issue of schools' carbon emissions (House of Commons, 2007, p. 15).

The above indicate the urgent calls for the government to ensure that BSF schools play a key role in addressing Climate Change issues. Among the major strategies advocated by several UK government reports to meet these pressing needs for sustainable energy and CO_2 emission reduction is technological innovation (Stern, 2006; DEFRA, 2007; Thalmann, 2007; DTI, 2007). The Stern Review on the economics of Climate Change emphasised that policy to encourage innovation and the implementation of low-carbon technologies is central to mitigating Climate Change (Stern, 2006). Indeed, technological innovation is seen as the dominant strategy for a smooth reduction in greenhouse gases emissions (Thalmann, 2007). Therefore, the implementation of SEI should be adequately encouraged on BSF school buildings in order to meet the government's energy efficiency and CO_2 emission reduction objectives.

Section 1.4 also introduced PFI as the Labour government's preferred delivery model for new-build schools within the BSF programme. The centrality of PFI to the government's BSF procurement policy thus necessitates adequate understanding of its capacity to encourage SEI. Certainly, the ability of PFI and the wider PPP delivery models to encourage innovation is widely endorsed in government guidelines (HM Treasury, 2003). In fact, the increasing potential for innovation on PPP/PFI delivery models is one of the key benefits advocated by their proponents (HM Treasury, 2000b). This is largely based on the belief that PPP/PFI models create an environment conducive to innovation and improved performance on construction projects. The private sector involvement in public service provision is seen to prompt their innovative capacity in a bid to maximise financial returns over the whole-life cycle of the project (Domberger and Jensen, 1997). The prevailing view is that PPP/PFI provides real incentives by putting in place unique cooperative arrangements between clients, designers, constructors, and operators (Leiringer, 2003). These cooperative arrangements in conjunction with added incentives and long-term commitments will ultimately lead to innovative solutions to the client service requirements. Indeed, Leiringer (2006) argues that PPP/PFI project models are somewhat envisaged as a vehicle for change and a panacea for the construction industry.

The innovative capacity of the PFI project delivery model is nowhere more needed than in meeting global pressures for sustainable energy and CO_2 reduction (Malmborg, 2007). Many commentators stress the importance of inter-organisational networks and partnerships in the future of environmental policy and management (Hartman *et al.*, 1999; Roome, 2001; De Bruijn and Tukker, 2002; Malmborg, 2007). Malmborg (2007) proposes that inter-organisational collaboration in networks and partnerships should actively promote the potential for learning and innovation needed for environmental transformation and sustainable development. Indeed, over the last decade, the concepts of improved inter-organisational cooperation and sustainability have been at the forefront of policy initiatives in construction (DETR, 2000ab; Egan, 1998; Latham, 1994). Several studies highlighted the importance of construction industry relationships for innovation (e.g. Nam and Tatum, 1989, 1992b; Miozzo and Dewick, 2002; Dubois and Gadde, 2002). Nam and Tatum (1989, 1992b) identified the strong need for long-term relationships between organisations in the construction industry to promote innovation. RCF (1998), also Seaden and Manseau (2001), highlight that policies promoting cooperative arrangements between organisations are effective innovation drivers. Dewick and Miozzo (2004), Dorée and Holmen (2004), and Holmen *et al.* (2005) similarly point out the essential role of strong inter-organisational relationships for technological innovation on construction projects.

However, whether the PFI project model delivers its promises as an arena for SEI is still to be determined. In fact, some authors have been highly critical of the innovative capacity of early UK PFI deals (Barlow and Köberle-Gaiser, 2008ab; Caldwell and Roehrich, 2008). Leiringer (2006) argues that there is an apparent discrepancy between the espoused outcomes of PPP/PFI project models, the supporting evidence, and the underlying theory. In fact, he goes so far as to contest that several publications that endorse PPP/PFIs as vehicles for innovation are largely based on anecdotal evidence and wishful thinking. Indeed, research studies into the innovative capacity of PPP/PFI projects are limited. The works of Leiringer (2003, 2006), Barlow and Köberle-Gaiser (2008ab), Eaton *et al.* (2006), Caldwell and Roehrich (2008), and Caldwell *et al.* (2009) are among the few that can be identified. This theoretical and empirical gap becomes even greater when examining the capacity of PPP/PFI project models to stimulate innovation for sustainability. The literature review conducted as part of this study could not identify any previous research that explored the relationship between PPP/PFI and sustainability innovation, including SEI. This represents a significant theoretical and empirical research opportunity because SEI is a global phenomenon that necessitates adequate understanding of the factors that influence its implementation and success. Therefore, given the urgent need for innovation to meet the challenges of Climate Change, as well as the centrality of PFI to the government's BSF procurement policy, it is important to understand the capacity of the PFI project delivery model to support the implementation of SEI on BSF new-build school projects. This need underlines our first research question, being:

Question 1: What is the capacity of the PFI project delivery model to support the implementation of SEI on BSF new-build school projects?

Certainly, the important role of public procurement as a driver for innovation has been strongly emphasised by European policymakers (European Commission, 2003). Public procurement forms a substantial percentage of total demand for goods and services, approximately 16% of the combined EU-15 GDP (European Commission, 2003). Whilst public procurement remains a largely understudied phenomenon (Brammer and Walker, 2007) the interest in the use of public demand as a vehicle for innovation has been increasingly taking precedence in current innovation policy debates, a process stimulated by the recommendations of a number of research studies and policy reports (e.g. Geroski, 1990; Dalpé *et al.*, 1992; Dalpé, 1994; Edquist, 1998; Edler *et al.*, 2005; European Commission, 2003, 2005). The public sector is generally considered a very 'demanding' customer, which requires innovative solutions to fulfil its role in society (Dalpé *et al.*, 1992). The emergence of new societal needs that become state priorities often provide opportunities and offer scope for innovative solutions (Edler *et al.*, 2005). Dalpé *et al.* (1992) argue that the public sector exerts strong pressures particularly in those technology areas with high innovation dynamics. Edler *et al.* (2005) emphasise that the purchasing power of the public sector is particularly important in sectors such as construction and energy in public buildings, where it constitutes the 'lion's share of demand'.

The effectiveness of public sector demand in stimulating innovation was also highlighted by Rothwell and Zegveld (1981) in their comparative study between R&D subsidies and public procurement contracts without a direct R&D element. Their findings suggest that, in the long-term, public sector demand generates greater innovation in more areas than R&D subsidies. Geroski (1990) also points out the quantitative and qualitative evidence of the effectiveness of public demand and concludes that public demand has a much greater impact on stimulating innovation than a wide range of R&D subsidies. Edler and Georghiou (2007) also maintain that public procurement can be designed to encourage innovation by arranging contracts to ensure that innovation is a key element. The role of public demand in encouraging sustainability innovation was also emphasised by the National Audit Office (NAO) (2009) when stating: 'The public sector has considerable buying power, and the ability to influence supply chains to address government priorities such as sustainability both directly and through encouraging innovation' (p. 20). Therefore, given the importance of the subject, this study seeks to expand previous research on public procurement of innovation by empirically examining the role of public demand, in the form of the government's PFI procurement policy, in supporting innovative sustainable energy solutions. By doing so, the study may lead to a greater awareness of how 'New Public Procurement Models' (Pryke, 2001; Barlow and Köberle-Gaiser, 2008) may work to encourage more innovative activity in the construction industry and to the growth or even creation of markets for innovative sustainable products and services (Erdmenger, 2003). Therefore, we forward our second research question:

Question 2: How can SEI be supported within the BSF PFI project delivery model?

It is necessary by this stage to explain the logic underpinning the research study. A central line of reasoning for this study is that innovation cannot be understood as an isolated decision-making process undertaken by one firm. Rather, innovation is a multidisciplinary activity spanning multiple organisations and circumstances (Kaatz *et al.*, 2005; Rohracher, 2003, 2005; Ornetzeder and Rohracher, 2006; Heiskanen and Lovio, 2007). Taking such a system-oriented perspective is particularly important for sustainability and environmental innovation. Scholars such as Rohracher (2001), Ornetzeder and Rohracher (2006) and Heiskanen and Lovio (2007) emphasise that the development of sustainable buildings involves increasing levels of functional dependency and components complexity. Therefore, these buildings can only be successfully constructed through closer interaction among suppliers, professionals, clients, and users (Rohracher, 2001). As will be further explained in Chapter 2, and following previous studies such as those of Barlow and Köberle-Gaiser (2008ab) and Caldwell *et al.* (2009) the BSF PFI project is conceptualised as a Complex Product Systems (CoPS) supply network (Hobday, 1998) where innovation success largely depends on the dynamic, collective, and interactive relationships among multiple project participants (Hobday, 1998, 2000; Hobday *et al.*, 2000; Gann and Salter, 2000; Davies and Salter, 2006). Hence, in order to examine the relationship between the PFI project model and SEI, it is necessary to consider the interactions between the different organisations involved in BSF PFI project developments. Particularly, and following from this conceptualisation is the view that SEI needs to be understood in terms of an interactive relationship among the public sector Client/User and the private sector Producer, and within the Producer's supply chain. In the case of BSF PFI projects, the public *Client* is represented by the Local Authority, the principal client for all building, ICT, and facilities contracts while the public *User* is the School, the ultimate user of the new facility. The private *Producer*, on the other hand, is ultimately the ProjectCo; the group of private sector actors who come together to bid for and, later, to implement the PFI project. Indeed, Howard and Caldwell (2011) argue that the management of innovation on PFI projects is particularly problematic as PFI project arrangements involve long-term interactions among public sector users and private sector producers, spanning multiple decades as the facility is designed, constructed, and used. Therefore, the need for close inter-organisational interaction in the development of SEI on the one hand, and the complexity of the PFI delivery model on the other, lead to increasing interest in the conditions under which SEI will take place.

Following the explanation of the study's key assumptions, and in order to adequately address the research issues, the two research questions are translated into five research objectives:

Objective 1: To identify key determinants of SEI postulated in CoPS Innovation Management Theory.

Objective 2: To identify key characteristics of the PFI project delivery model within the context of BSF new-build school projects.

Objective 3: To develop a conceptual framework to examine the capacity of the PFI project delivery model to support the implementation of SEI based on innovation determinants postulated in CoPS Innovation Management Theory.

Objective 4: To examine the capacity of the PFI project delivery model to support the implementation of SEI based on the developed conceptual framework.

Objective 5: To propose potential solutions to the problematic issues identified in the implementation of SEI within BSF PFI projects.

The next section will highlight the value of the research study, focusing on the importance of the research issue, gaps in the literature, and potential benefits of research outcome.

1.6 Value of the Research Study

1.6.1 Importance of the Research Issue

The need to understand the enablers and barriers to the implementation of sustainability in construction projects is paramount (Sexton, 1997). To Sexton, (1997) 'If the human race is to develop and prosper in the third millennium, organisations both on the supply and demand sides of the construction industry must play their part and develop new organisational perspectives and practices that harmonize their activities with environmental interests to ensure sustainability' (p. 150). Rohracher (2001) also highlights that the problem of making buildings more sustainable is only to a limited extent a technical one. Indeed, existing developments in construction technologies and building components can further reduce the ecological load of buildings to a fraction of their current value (Rohracher, 2001). However, the necessary change of technologies can only be managed by simultaneously considering technical possibilities and their social context (Latour, 1987; Rohracher, 2001; Ryghaug & Sørensen, 2009; Guy and Shove, 2000). Sexton (1997) suggests that an investigation of why the required change towards sustainability is being obstructed will provide not only a better understanding of the complex situation, but also provide useful directional insights into how to overcome these blockages.

1.6.2 Gaps in the Literature

There is an apparent lack of adequate research into the innovative capacity of PPP/PFI project models, particularly within the field of construction management research (Demirag *et al.*, 2004; Raisbeck, 2008). In fact, the works of Leiringer (2003, 2006), Eaton *et al.* (2006), Barlow and Köberle-Gaiser (2008ab), Caldwell and Roehrich (2008), and Caldwell *et al.* (2009) are among the few that can be identified. In addition, there has been no attempt to explore the relationship between PFI and sustainability innovation, including SEI. Thus, this study will attend to a significant research opportunity as there is a lack of conceptual and empirical work providing recommendations on managing innovative processes for sustainable energy in PFI projects. Furthermore, studies exploring the management of environmental issues within construction are also limited. Shen *et al.* (2008) mention that studies that explored the barriers to implementing environmental management in construction are predominantly concerned with examining the nature of construction activities rather than the management strategies that drive sustainable practice. Similarly, Georg and Füssel

(2000) demonstrate that the majority of research studies on greening organisations have focused on outcomes, with limited attention given to process. This research will explore management-related factors affecting the implementation of SEI in BSF. The opportunities and challenges facing the various parties involved in BSF PFI projects will be identified to provide valuable contributions to sustainable development. By considering the process through which decisions are made, it becomes easier to see where the impediments and motivations for SEI in BSF PFI projects lie.

1.6.3 Potential Benefits of Research Outcome

The research findings will be beneficial to a wide range of individuals, from those concerned with sustainability and public procurement to those working on PPP/PFI projects. While the BSF programme was halted in July 2010, the findings may benefit future capital investments using PFI. The findings will have specific value in the development of SEI for both the public sector clients in central and local government as well as private sector actors working on PFI projects in various roles, from building contractors, architects, facility managers to financiers. The findings may increase public sector clients' awareness of how they can utilise the PFI project delivery model to support SEI effort. Private sector actors can also benefit from the research findings, particularly those firms in the construction industry that seek to create competitive advantage through SEI. The study will also be of interest to change agents and researchers working on other BSF projects, for two reasons. First, the methodology can be replicated to develop an in-depth understanding of the innovation process in other BSF projects. Second, the findings that result from the study can be applied, compared, and contrasted with other BSF projects and can aid in identifying barriers to the implementation of sustainability in general, and SEI in particular, within BSF PFI projects. This research also intends to have a practical and policy contribution to BSF. The study will develop potential solutions to the problematic issues identified in the implementation of SEI within BSF PFI projects. This will largely benefit future capital investments that intend to use the procurement model to deliver public sector assets. It will also identify future research agenda on sustainability innovation within PFI projects. In summary, the research study is directed towards enabling reforms to make PFI operations more energy-efficient and environmentally sustainable.

1.7 Scope of the Study

The scope of the research is primarily confined to the achievement of SEI within BSF PFI projects. BSF projects that were delivered under Design and Build (D&B) or framework agreements are not included in this study. In addition, the study explores the implementation of energy-related sustainability innovation. Therefore, other sustainability efforts outside the scope of energy were not considered. Initiatives toward other environmental aspects such as rainwater-harvesting technologies as well as economic and social sustainability initiatives, while observed during data collection, were excluded from the study. In addition, the study primarily focuses on the design and construction phases of the BSF PFI projects, thus excluding the operation phase. Three of the case studies examined were in their early operational stages, while the fourth was still on-site when data was collected. Therefore, it was not possible to investigate operational energy efficiency outcomes and performance management results. The financial success of the projects, particularly whether or not the projects were delivered on time and within budget, is also outside the scope of the study. The long horizon of PFI also made it impossible by this stage to assess the successful achievement of overarching project life-cycle objectives.

1.8 Research Development Stages

This research study adopted a six-stage research development process in order to fulfil the stated research questions and objectives. The six interrelated and overlapping stages are as follows:

- **Stage 1:** This stage included extensive literature review on innovation, examining leading academic and technical journals, technical reports, text books, case studies, and government guidelines and reports. A theoretical description of project-related SEI was developed based largely on a thorough review of mainstream, CoPS as well as construction-specific innovation literature. The output of this stage forms Chapter 2 of this thesis report.

Stage 1 provided the information needed to fulfil Objective 1 and that is to identify key determinants of SEI postulated in CoPS Innovation Management Theory.

- **Stage 2:** This stage involved a thorough review of the literature on PPP, PFI, and BSF Projects to identify key characteristics of BSF PFI project delivery model. The literature review examined refereed academic and technical journals, technical reports, manuals, conference proceedings, case studies, business and financial press, and official government reports and guidelines. The output of this stage forms Chapter 3 of this report.

Stage 2 provided the information needed to fulfil Objective 2 and that is to identify key characteristics of the PFI project delivery model within the context of BSF new-build school projects.

- **Stage 3**: This stage sought to ascertain current practice and increase the understanding of key actors' motivations for entering into BSF PFI projects and their objectives and expectations in terms of innovation, sustainability and energy efficiency. This stage involved 15 semi-structured interviews with senior representatives of both public and private organisations involved in BSF development. This helped to streamline the study through the identification of core areas of interest. Appendix B provides a list of introductory interview participants.

- **Stage 4:** The literature review from Stages 1 and 2 together with the insights gained from the introductory interviews in Stage 3 were utilised to build a conceptual framework to examine the capacity of the BSF PFI project delivery model to support SEI. Six conceptual propositions were developed and later used as templates for data collection and analysis. The output of this stage constitutes Chapter 4 of this report.

Stages 3 and 4 fulfilled Objective 3 by developing a conceptual framework to examine the capacity of the PFI project delivery model to support the implementation of SEI based on innovation determinants postulated in CoPS Innovation Management Theory.

- **Stage 5:** This stage developed a research strategy to test the conceptual framework developed in Stage 4. The research strategy guided the process through which detailed fieldwork was undertaken, an extensive amount of data collected, in-depth analysis conducted, and testing of emergent findings carried out. A qualitative multiple case study research strategy was adopted based on replication logic. Four case studies were selected following set criteria to ensure comparability and to maximise what could be learned from the study. Three case studies were selected on the grounds that they showed at least one significant SEI, and one case study was selected on the ground that it showed no evidence of SEI. Data was collected through semi-structured interviews with ProjectCo, Local Authority, and School representatives from each case study. This ensured triangulation of the data collected and improved its validity. Data collection also involved extensive review of BSF and project-specific documentation. Literal replication was sought on the three innovative projects, while theoretical replication was sought on the fourth. The output of this multiple case study research strategy forms Chapters 6–11 of this report.

Stage 5 fulfilled Objective 4 by utilising case studies to examine the capacity of BSF PFI project delivery model to support the implementation of SEI. This involved conducting in-depth analysis of data collected from the multiple case studies and identifying the extent to which the six conceptual propositions developed in stage 4 were supported on the case study projects. The findings also outlined the main problematic issues confronted by firms pursuing SEI on BSF PFI projects.

- **Stage 6:** This stage examined the identified problematic issues in the implementation of SEI within BSF PFI projects and developed solutions to remedy their effect. This was pursued by using theoretical and a priori reasoning which builds on the findings from all previous stages. The output of this stage was outlined in Chapter 11 (Section 11.4) of this thesis report.

Stage 6 fulfilled Objective 5 by proposing potential solutions to the problematic issues identified in the implementation of SEI within BSF PFI projects. The findings from the six-stage research development process fulfilled the two research questions and five research objectives as shown in Table 1.1 below.

Table 1.1: Research Development Stages

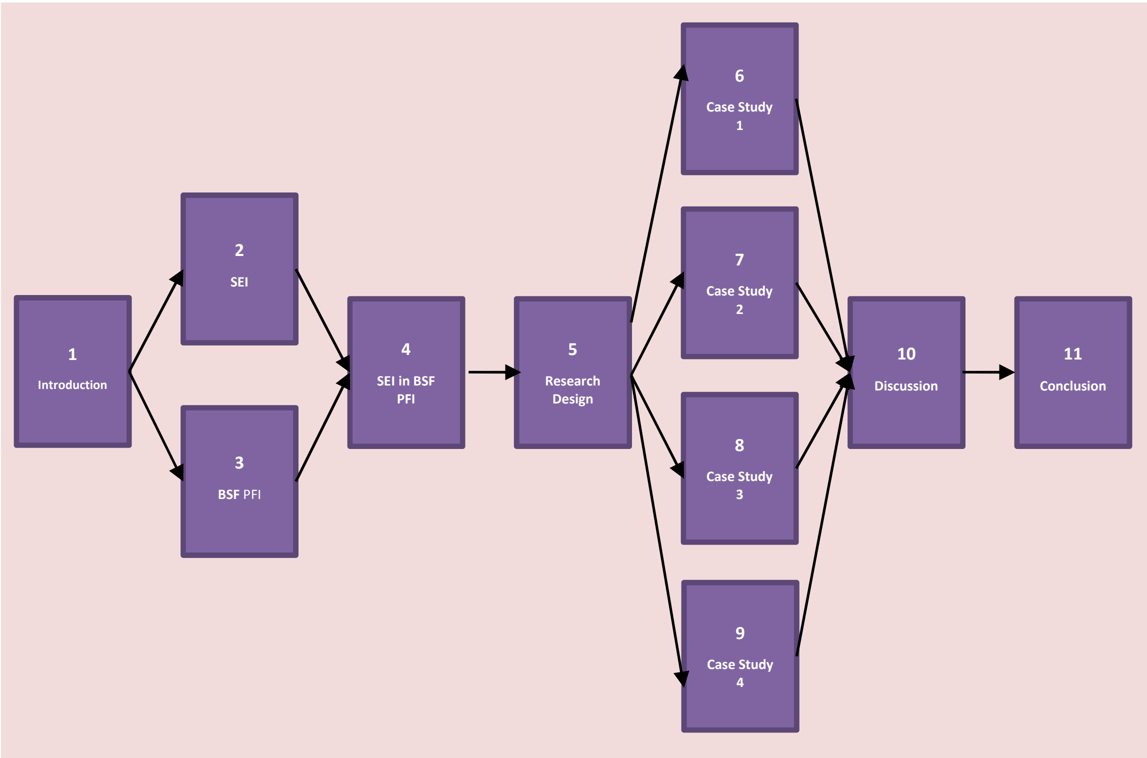
Research Questions	Research Objectives	Research Stage	Research Tools	Thesis chapters
Question 1: What is the capacity of the PFI project delivery model to support the implementation of SEI on BSF new-build school projects?	**Objective 1:** To identify key determinants of SEI postulated in CoPS Innovation Management Theory.	Stage 1	Review of leading academic and technical journals, technical reports, text books, case studies, and government guidelines and reports.	Chapter 2
	Objective 2: To identify key characteristics of the PFI project delivery model within the context of BSF new-build school projects.	Stage 2	Review of leading academic and technical journals, technical reports, text books, conference proceedings, case studies, the financial/business press, official reports, and government guidelines.	Chapter 3
	Objective 3: To develop a conceptual framework to examine the capacity of the PFI project delivery model to support the implementation of SEI based on innovation determinants postulated in CoPS Innovation Management Theory.	Stage 3	Introductory interviews with both public and private sector BSF participants.	-
		Stage 4	Developing a conceptual framework to examine the capacity of the PFI project delivery model to support the implementation of SEI, based on innovation determinants postulated in CoPS Innovation Management Theory.	Chapter 4
	Objective 4: To examine the capacity of the PFI project delivery model to support the implementation of SEI based on the developed conceptual framework.	Stage 5	Develop a research methodology and strategy to test the conceptual framework Data collection Within-case analysis Cross-case analysis	Chapter 5 Chapter 6 Chapter 7 Chapter 8 Chapter 9 Chapter 10 Chapter 11
Question 2: How can SEI be supported within the BSF PFI project delivery model?	**Objective 5:** To propose potential solutions to the problematic issues identified in the implementation of SEI within BSF PFI projects.	Stage 6	Theoretical and a priori reasoning.	Chapter 11

Source: Developed for this research study

1.9 Structure of the Report

An eleven-chapter structure has been developed to present this thesis in an effective and comprehensible manner. Figure 1.5 (Page 26) displays this structure.

Figure 1.5: Structure of the Report



Source: Developed for this research study

Chapter 1: Introduction

This Chapter outlines the broad field of the study and leads into the focus of the research problem. The research question and corresponding research issues are presented and the value and scope of the study outlined.

Chapter 2: Innovation Management Theory

This Chapter explores innovation taking a wide approach to embrace several different perspectives of the concept. Attention is then focused on CoPS Innovation Management Theory and key determinants for innovative activities are presented. Determinates of innovation in the construction industry are also explored. The Chapter concludes with identifying key determinants of SEI postulated in CoPS Innovation Management Theory.

Chapter 3: The Private Finance Initiative (PFI)

This Chapter introduces the concept of PFI and its application within the BSF context. Several definitions of the concept are presented, and the roles of the key parties involved and the main phases of the project outlined. The Chapter also explores key characteristics of the PFI project delivery model that distinguish it from other procurement strategies.

Chapter 4: Building the Conceptual framework

This Chapter seeks to marry the concepts of PFI and innovation in order to develop a conceptual framework that enables the examination of SEI within BSF PFI projects. The result is the development of six propositions linking the PFI project model with innovation determinants postulated in CoPS Innovation Management Theory. These six propositions will form the conceptual bases upon which the empirical findings from the case studies will be tested.

Chapter 5: Research Design and Methodology

This Chapter justifies the research design and methodology adopted to collect the field data in order to address the identified research issues. Building on that, the process of data collection will be discussed.

Chapters 6–9: The Case Studies

These chapters present the individual cases. Case study findings are organised according to the six research propositions developed in Chapter 4 and illustrated with quotes from the case study participants.

Chapter 10: Discussion

This Chapter discusses the findings from the multiple case studies with regard to the six propositions developed in Chapter 4.

Chapter 11: Conclusion

This Chapter provides a summary of the research study, presenting the key conclusions and recommendations that have been developed. Future research directions are also suggested.

1.10 Summary

This Chapter has laid the foundation for the main part of the thesis. First, the Chapter introduced the research context. The need for technological innovation to meet the global calls for sustainable development and sustainable energy was highlighted. It also outlined key global and national policies to reduce energy consumption in buildings, with a particular focus on school buildings. The Chapter then focused on the Private Finance Initiative (PFI) as a delivery model for UK school buildings. The model was briefly explained and the objectives behind its adoption as the preferred delivery model for new-build schools within BSF were highlighted. The fifth section explored the research issue, questions, and objectives, explaining the need for adequate assessment of the capacity of PFI project delivery model to encourage SEI within BSF school buildings. The value of the research study was then highlighted, focusing on the importance of the research issue, gaps in the literature, and potential benefits of research outcome. The study's scope was explained, the research development stages described and the structure of the report outlined. On these foundations, the report can proceed by building the necessary theoretical base for the research.

Chapter 2: Innovation Management Theory

2.1 Introduction

The purpose of this Chapter is to meet the study's first objective by identifying the key determinants of Sustainable Energy Innovation (SEI) postulated in Innovation Management Theory. Whilst several government reports highlighted the importance of innovation in meeting the urgent call for sustainable energy and CO_2 emission reduction (Stern, 2006; DEFRA 2007; Thalmann, 2007; DTI, 2007), such innovations are, however, still in their early development stages (Kelly, 2008). Rennings (1998) emphasise the need for further research to develop a better understanding of environmental innovation processes in their different dimensions; complex feedback mechanisms and interrelations. In the construction industry context, Dewick and Miozzo (2004) argue that the pressure to meet new demands for sustainable technologies and processes presents a considerable challenge for the network of organisations involved in the construction process. Similarly, many commentators emphasise the need for greater exploration of the issues generating a favourable environment for innovation in construction projects (e.g. Winch, 1998; Dulaimi *et al.*, 2003).

The Chapter will describe innovation and aspects of innovation from several perspectives, providing a broad description of the concept and then proceeding towards the specific category of innovation in the construction industry. Therefore, the Chapter is divided into two distinct sections. The first section introduces the concept of innovation from mainstream innovation theory perspective. Taking this point of departure is necessary because a description of general innovation literature will provide a better understanding of the fundamental issues underlying innovation in the construction industry (Leiringer, 2003). The section will highlight several definitions of the concept of innovation and develop the definition of SEI upon which this research study is rooted. It then proceeds to explaining the CoPS perspective adopted on this research study to the implementation of SEI, focusing on its significance in understanding determinants of innovation on BSF PFI projects. However, innovation is an increasingly diverse subject and hence an all-encompassing description of the underlying arguments is difficult. Therefore, attempts were made at times to simplify and generalise to allow for further development of the subject in the second section dealing with the concept of innovation as it applies to the project-based construction industry. The Chapter concludes with a summary of key conceptual issues identified.

2.2 Theoretical Perspectives on Innovation

2.2.1 What is Innovation?

The study of innovation dates as far back as 1911, and Joseph Schumpeter's seminal work, *Theory of Economic Development* (Schumpeter, 1947, 1980) described innovation as a historic and irreversible change in the way of doing things. The essence of Schumpeter's definition of innovation is that it is an effort made by an entity that results in an economic gain, either by reducing cost or increasing income (Smith, 1998; Sundbo, 1998; Cobbenhagen, 2000). Schumpeter also distinguishes between five types of innovation: (1) introduction of a new product or a qualitative change in an existing product; (2) process innovation new to an industry; (3) opening of a new market; (4) development of new sources of supply for raw materials or other inputs; and (5) changes in industrial organisation (Schumpeter, 1980). Rogers (2003), another important contributor to the study of innovation, described the concept of innovation as a process initiated by the invention of a new technological element, such as an idea, practice, or project, which in turn leads to the development of the element into practical and commercial use. The success of this commercialisation will ultimately result in widespread diffusion and imitation (Sundbo, 1998). Other definitions of innovation are provided by Freeman (1989), Firth and Mellor (1999), and Atkin (1999):

> The actual use of a nontrivial change in a process, product or system that is novel to the institution developing the change (Freeman, 1989, p. 11).

> The application of new knowledge to industry, and includes new products, new processes, and social and organisational change (Firth and Mellor, 1999, p. 199).

> When an act, as an idea, begins to impact on its environment (Atkin, 1999, p. 4).

Freeman's (1989) definition indicates that, to be considered an innovation, the change should be nontrivial, novel, and can be regarded as a significant improvement to existing products or practices. This definition of Freeman (1989) is the definition of innovation upon which this research study is rooted. Indeed, Lenard (2001) and Barrett *et al.* (2001) argue that change for its own sake does not necessarily produce benefits, and innovation is fundamentally a *positive* change. The degree of novelty of the proposed change has also been the subject of long-standing debate, particularly whether a distinction could be made between innovation and diffusion. While Freeman (1989) made a clear distinction between the two, a consensus is yet to be reached and some commentators argue that a clear separation between the two concepts is not possible (Marquis, 1988; Smith, 1998).

Another important distinction could be made between *innovation* and *invention*. Slaughter (1998) defines invention as a detailed design or model of a product (or process) that can be clearly distinguished as novel to the existing art. Innovation, on the other hand, is the application of a particular invention into commercial use. Therefore, an innovation can certainly be an invention, but an invention is not necessarily an innovation, unless it has progressed through production and marketing tasks and is diffused into the market place, providing economic value to the innovators (Freeman, 1991; Garcia and Calantone, 2002). Another differentiator between the two concepts is provided by Kemp and Foxon (2007) who argue that while invention fundamentally refers to discovery, innovation is often the outcome of applied Research and Development (R&D) and search processes. An example given is 'Halogen lighting', which not only is a scientific discovery, but also a combination of multiple knowledge on user behaviour, production technology, and standards (Kemp and Foxon, 2007). A distinction could also be made between *innovation* and *creativity*. Amabile *et al.* (1996) explain that while creativity is the production of novel and useful ideas by individuals and teams, innovation is the implementation of the creative ideas within an organisation. Creativity is the starting point of innovation (Amabile *et al.,* 1996).

The OECD Guidelines for Collecting and Interpreting Technological Innovation Data (OECD, 2005) make a distinction between 'technological', 'marketing' and 'organisational' innovation. *Technological innovation* is mainly derived from research and can be divided into 'process' and 'product' innovation. Process innovation takes place when a given amount of outputs, (e.g. goods and services) can be produced with fewer inputs. Product innovation occurs when improvements are introduced to existing goods (or services) or the development of new goods. *Marketing innovation* requires the implementation of new marketing methods to increase business sales. *Organisational innovation* or 'Business Model Innovation' is linked to innovative organisational practices such as just-in-time manufacturing (Choudri, 2002), total quality management (Montgomery, 2005; Aucoin, 2000), and lean supply chain and customer management (Womack *et al*., 2007).

Particularly important to this research study is *technological product innovation,* as the SEIs studied predominantly fall within this category of innovation. A technological product innovation can take two distinct forms: a technologically new product and a technologically improved product. Some argue that a clear distinction between the two forms is difficult to determine (Leiringer, 2003). A technologically new product is defined by the OECD (2005) as:

> A product whose technological characteristics or intended uses differ significantly from those of previously produced products. Such innovations can involve radically new technologies, can be based on combining existing technologies in new uses, or can be derived from the use of new knowledge (OECD, 2005, p. 32).

Whereas, a technologically improved product is defined as:

> An existing product whose performance has been significantly enhanced or upgraded. A simple product may be improved (in terms of better performance or lower cost) through use of higher-performance components or materials, or a complex product which consists of a number of integrated technical sub-systems may be improved by partial changes to one of the sub-systems (OECD, 2005, p. 32).

SEIs can take both forms. They can be distinctly different technological solutions, or existing products, the technical performance of which has been significantly enhanced (Shrivastava, 1995; Fussler and James, 1996; James, 1997; Belz and Peattie, 2009). The next section focuses on the specific category of environmental innovation and develops the definition of SEI that is adopted in this research study.

2.2.2 Innovation for the Environment

SEI is a particular subset of environmental innovation, which has been broadly defined by Dewick and Miozzo (2002) as the use of production equipment, techniques, procedures, products, and product delivery mechanisms that are sustainable; i.e. they conserve resources and energy, minimise environmental impact, and protect the natural environment. Mostly, innovation for sustainable energy involves two main strategies: energy efficiency and renewable energy (REEEP, 2004). From a mechanical standpoint, *Energy Efficiency* is essentially the reduction of energy inputs for a given level of service, or enhancing the services for a given amount of energy inputs (National Science Foundation, 2009). Increased energy efficiency can also refer to end-use energy conservation measures to reduce total energy consumption (Intrachooto, 2002). Increased energy efficiency can lead to decrease in energy costs (for suppliers and consumers), as well as reduction in CO_2 emission levels (National Science Foundation, 2009). Energy-efficient technologies in buildings may include solutions for facility management, such as heating systems, new insulation materials, and energy management systems (Action Energy, 2002; Fowler and Rauch, 2007). They may also involve strategies to utilise the building mass for heat storage, employing natural ventilation to provide free cooling, and adopting innovative strategies for recycling energy, such as heat recovery technologies (Wasserman, 1995; Intrachooto, 2002).

Renewable Energy, on the other hand, is the second strategy for sustainable energy and the category most often associated with the term (Prindle *et al.*, 2007). Renewable energy is defined as 'a flow of energy that is not exhausted by being used' (Sørensen, 1991, p. 386). Hence, renewable energy technologies are means by which such flows are converted into applicable devices (Sjöö, 2008). Renewable energy resources include the sun, wind, water currents, the heat of the Earth, and replaceable fuels such as from plants. As well as reducing stratospheric ozone depletion, acid precipitation, and the greenhouse effect, renewable energy resources are considered one of the most efficient and effective solutions (Dincer and Rosen, 1999; Dincer, 2000). There are no CO_2 emissions resulting from energy consumption as renewable energy generation using the heat of the sun, heating or cooling from ground sources, and wind energy are all essentially free of the emissions (DCSF, 2007b).

It is appropriate at this stage to develop a definition of Sustainable Energy Innovation (SEI) that will be adopted on this research study. To minimise the diverse and possible conflicting interpretations and to avoid misinterpretation, the *sustainable energy* and *innovation* terms were established at the outset of the study and defined the scope of the investigation. Innovation fundamentally implies novelty and improvement. The study adopts Freeman's (1989) definition of innovation as a non-trivial improvement in product, processes, and systems that are actually used and are novel to the organisations developing and using them. *Novelty* on this study does not strictly imply new concepts or technologies that have never been used before. It also includes adopted solutions or technologies that have been successfully employed elsewhere but are unique to the particular industry, geographic location of the project, or the situation under study. Taking the definitions of *energy efficiency* and *renewable energy* into consideration, the term SEI is used on this research to represent technological products and solutions that are successfully integrated into building's design strategies to either increase energy efficiency or utilise renewable energy generation. Therefore, it encompasses the two pillars of sustainable energy suggested by Prindle *et al.* (2007). The following definition of SEI is developed for this research study:

> Sustainable Energy Innovations (SEIs) are novel technological products or solutions that are successfully integrated into building's design strategies in order to prevent or substantially reduce the negative impacts of energy use by increasing energy efficiency, or utilising new ways of renewable energy generation.

The following sections will further explore the subject of innovation, outlining the different types of innovation and then explaining the key determinants for SEI postulated in different theoretical approaches to innovation. The discussion will then proceed to explaining the study's 'Complex Product Systems (CoPS)' perspective to SEI and its implementation on the project-based construction industry.

2.2.3 Types of Innovation

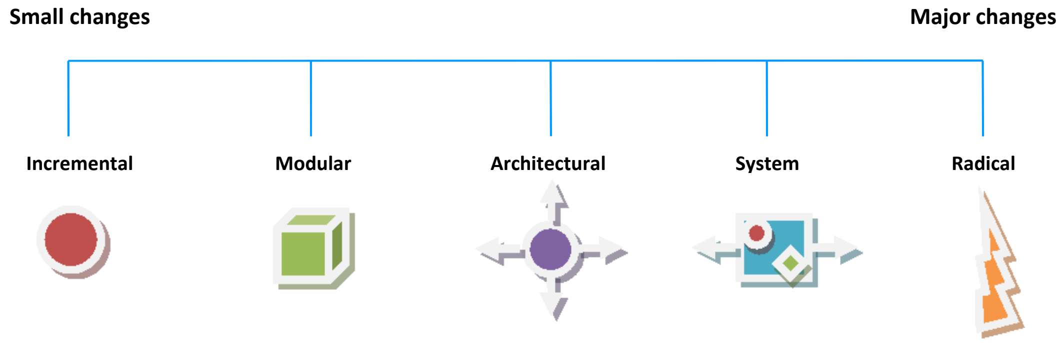
Innovation can take many forms. Henderson and Clark (1990), Slaughter (1998) and Taylor and Levitt (2004) identify five types of innovation:

- **Incremental Innovations**: are those that reinforce existing products or processes, and are often based on current knowledge and experience (Slaughter, 1998; Taylor and Levitt, 2004). The impact of the change is usually limited to the specific product, with links to other components remaining unchanged, and is often highly predictable (Slaughter, 1998). The implementing organisation is the entity ultimately affected by the incremental innovation (Abernathy and Clark, 1985; Henderson and Clark, 1990). Incremental innovations are valuable sources of productivity and environmental improvements (Kemp and Foxon, 2007).

- **Modular Innovations:** are those that produce a fundamental change in concept within a component, but with minimal change to linkages to other components or systems, and with moderately low impact (Slaughter, 1998). Modular innovations often significantly improve the performance of a product or sub process by introducing new and patented devices. However, other related components, materials, or methods remain unchanged (Slaughter, 1998). Modular innovations mostly affect the implementing entity (Henderson and Clark, 1990).

- **Architectural Innovations:** are those that bring about new configurations of an established system by linking existing components in a new way. In contrast to modular innovation, it involves a small change within a component, but a considerable change in the linkages to other existing components and systems (Henderson and Clark, 1990). An architectural innovation often carries significant implications for the interrelated organisations implementing the innovation (Henderson and Clark, 1990).

Figure 2.1: The Scale of Innovation Model



Source: Slaughter (1998)

- **System Innovations**: are those that involve significant changes to both the components and the linkages between them. System innovation is likely to integrate several independent innovations in order to perform new functions or improve the overall performance of a system. It often stems from multiple sources and should be explicitly coordinated (Slaughter, 1998). A system innovation involves significant implications for the interrelated organisations implementing the innovation (Henderson and Clark, 1990).

- **Radical Innovations**: are those that result in a breakthrough in a specific field and could bring about significant change in the dynamics of a whole industry (Marquis, 1988). Radical innovations result from entirely new approaches to understanding and problem-solving (Slaughter, 1998). They bring about new systems and components by establishing new sets of core design concepts. Radical innovation may necessitate a complete overhaul to existing linkages among systems and organisations (Foster, 1986; Kleinschmidt and Cooper, 1991; Utterback, 1994).

Incremental innovations are often seen to be easier to diffuse than those which are system or radical (Negro, 2008, 2010). This is based on the growing belief that technological change develops in certain directions along trajectories (Nelson and Winter, 1977, 1982; Arthur, 1989; Unruh, 2000). Particularly important to this trajectile nature of technological change is the socio-technical dimension stabilising search activities and patterns of technological change (Dosi, 1982). It is commonly acknowledged that a process of *mutual adaptation* takes place between an innovation and the environment in which it is produced and used, ultimately resulting in complete market dominance of a particular technology at the expense of other technologies, a situation Arthur (1989, 1994) termed '*technological lock-in*'. Indeed, Unruh (2000) argues that the dominance of fossil-fuel-based energy systems is the result of such a process of co-evolution (Unruh, 2000; North, 1990). The accumulated knowledge, skills, and expertise coupled with capital outlays, infrastructure, and regulation ultimately resulted in what he termed the '*carbon lock-in'* leading to the current prevalence of high carbon technologies. Newly developed SEIs may, hence, need to challenge existing fossil fuel technologies that are embedded in a socio-technical system that is large, well-functioning, and thus resistant to change (Negro, 2010). Therefore, diffusion under these circumstances is likely to be difficult, particularly in the case of radical (Christensen and Rosenbloom, 1995), disruptive (Christensen, 1997; Hamel, 2000) or system innovations (Rip and Kemp, 1998). Yet, incremental innovations that support existing products or processes are unlikely to experience such difficulties (Negro, 2008, 2010).

This bias towards incremental innovation, however, is seen to be detrimental as it moves environmental innovation efforts further away from the types of innovation with the greatest impact and potential to realise sustainability objectives (Huesemen, 2003). Indeed, incremental innovation is seen to be insufficient to deal with the magnitude of change needed. As Enkvist *et al.* (2008) argue: 'Incremental improvement of today's technology and energy consumption patterns can have a significant effect but will not come close to the necessary increase in carbon productivity' (p. 2). Instead, what is needed is that products, services, and systems be significantly reconstructed through more radical innovation (Huesemen, 2003; Hellstrom, 2006).

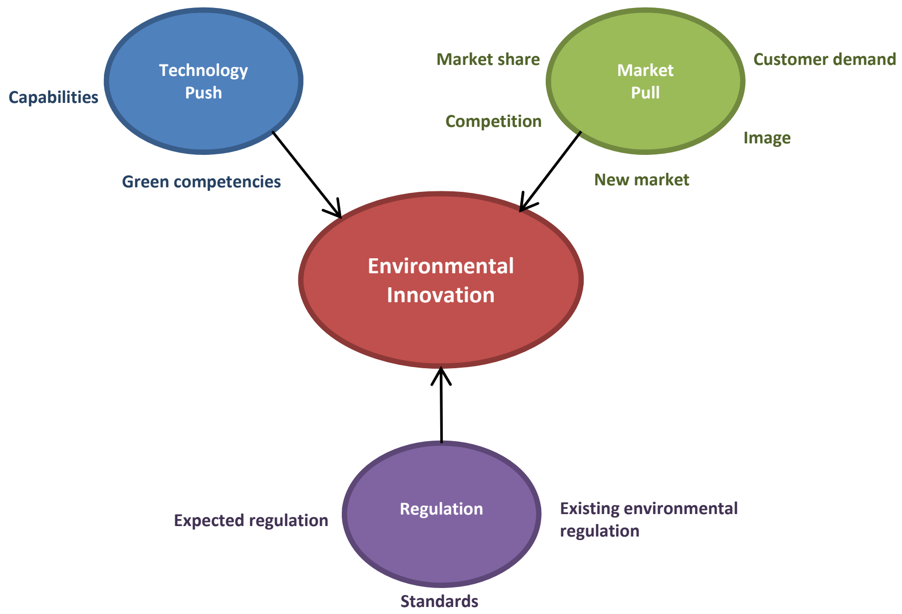
2.2.4 Determinants of Innovation

Several authors have argued that traditional Innovation Management Theory is valuable and applicable to environmental innovation (Johansson and Magnusson, 1998; Foster and Green, 2000; Magnusson, 2003). Foster and Green (2000) maintain that 'much of the theory that explains innovation, and the factors associated with successful innovation in a broader sense, can explain the action of innovating business in response to green issues' (p. 301). This section will outline two key theoretical models of innovation management. First, it will explore main linear Schumpeterian models of innovation. Then, it will proceed to explaining the Complex Product Systems (CoPS) model, more suitable to understanding the dynamics of innovation in project-based settings.

1. Linear Schumpeterian Models of Innovation Management

Among the earliest conceptualisations of the innovation process is that developed by Schumpeter, as far back as 1911 (Schumpeter, 1980). Schumpeter proposed that innovative processes could be understood as a three stage model: *invention*, the discovery of a new principle; *innovation*, the development of an invention into a commercial entity; and *diffusion*, the expansion of an innovation into commercial use (Schumpeter, 1980; Smith, 1998). This 'linear' and 'rational' perspective to innovation has been historically dominating most mainstream innovation literature as well as the specific field of construction innovation (Winch, 1998; Leiringer, 2003). The theory calls attention to the importance of 'technology-push' and 'market-pull' factors for explaining innovation activities (Horbach, 2008). Technology-push factors are largely seen to be particularly essential during the invention stage of developing a new product, while market-pull factors are important during the diffusion stage (Rehfeld *et al.*, 2007; Pavitt, 1984). With regard to environmental innovation, Horbach (2008) points out that the majority of environmental problems represent negative externalities, i.e. they impose a negative side effect on a third party. Thus, there are limited economic incentives for firms to develop environmentally friendly products and processes. Therefore, as Horbach (2008) maintains, general innovation theory needs to be extended to encompass the influence of environmental regulation. Figure 2.2 illustrates the three key determinants of environmental innovation.

Figure 2.2: Determinants of Environmental Innovation



Source: Horbach (2008)

i. Technology-push (Supply-side)

General Innovation Management Theory stresses the importance of a firm's technological capabilities for its innovative capacity (Baumol, 2002; Rosenberg, 1974). A firm's technological capabilities are ultimately defined by its physical and knowledge capital, with investments in R&D and education of employees as necessary ingredients to increase and intensify such a capital (Baumol, 2002). Baumol (2002) emphasises that the higher the technological capabilities of a firm, the more likely it will develop further innovation in the future. According to Baumol, (2002) 'innovation breeds innovation' (p. 284), pointing to the path-dependent characteristic of innovation. For the transition towards environmental innovation, Manzini (1999) argues that firms must 'learn how to compete, and possibly to make good business while decreasing the total production and consumption of physical goods' (p. 434). Such efforts may involve energy efficiency, reduction of waste, and enhanced product quality (Engels, 2007).

ii. Market-pull (Demand-side)

The market-pull argument is based on the belief that technological change must originate 'primarily from the business sector and depends mostly on corporate investments in response to economic incentives' (OECD, 2008, p. 13). Market-pull factors driving environmental innovation may include issues such as competitiveness (Acs and Audretsch, 1987; Gladwin, 1993; Sarkis, 1995; Henriques and Sadorsky, 1996) and customer demand for green products (Williams *et al.*, 1993; Steger, 1993; Elkington, 1994; Drumwright, 1994; Howes *et al.*, 1997). For example, Elkington (1994) argues that one of the most significant pressures forcing firms into addressing environmental concerns is the emergence of the 'green consumer'. Williams *et al.* (1993), Steger (1993) and Drumwright (1994) also found that green consumerism is among the chief pressures shaping a firm's 'selection environment', defined as the external factors that influence which products or processes a firm chooses to develop (Nelson and Winter, 1982). Indeed, Green *et al.* (1994) and Angel and Huber (1996) point out that major changes have been introduced to firms' selection environments as a result of the recent rise in sustainability and environmental issues. In addition, the potential economic reward for 'going green' is seen as the main motivator for firms to assume an environmental market-driving position (Esty and Winston, 2006). Indeed, Doerr (2006) argues that 'innovation in green technology could be the biggest economic opportunity of the 21st Century' (p. 1).

iii. Environmental Regulation

Environmental regulation is regarded as one of the main determinants for environmental innovation (Porter and van der Linde, 1995). A major characteristic of environmental innovation is their 'public good' nature. This means that while the cost of the innovation is often borne by the innovating organisation, the whole society will benefit from the innovation. For example, while an organisation will invest to develop and implement a product or process that produces less harmful CO_2 emissions, society as a whole will benefit from the cleaner air. However, this often results, particularly at the early stages of innovation, in development costs being uncompetitive, and no one firm is willing to pay for this public benefit (Rennings, 1998; Lehr and Löbbe, 2000; Beise and Rennings, 2005). Thus, Rennings (1998) argues that competition between traditional and environmental innovation will remain distorted, as long as markets do not charge for negative environmental impacts, i.e. if the costs of environmental damages continue to be negative externalities. Therefore, the government play an important role in fostering environmental innovations through policy measures, such as regulations that serve to address this imbalance (Hayes, 2007; Yeow *et al.*, 2011). The OECD (2008) proposes that 'in the case of innovation oriented towards a public good like the environment, market-pull is inoperable unless governments adopt regulation and put in place measures that increase the market value of environmental technologies' (p. 16).

Indeed, Porter and van der Linde (1995) advocate that environmental regulation may result in a *win-win* situation: pollution being reduced and profits increased. This argument is famously termed the *Porter Hypothesis* and is largely based on evolutionary innovation theory (Nelson and Winter, 1982). Porter and van der Linde (1995) maintain that environmental regulation can play a critical role by forcing firms to bring about 'economically benign environmental innovation'. For example, the Catalytic Converter was developed following regulations to protect local air quality, and resulted in significant reduction in emissions of pollutants such as NO_x and SO_x from vehicles (Kemp and Foxon, 2007). However, Porter's *win-win* hypothesis was a subject of considerable debate by neo-classical economists who argue that regulation may encourage firms to develop environmental innovation; yet the cost of such efforts will only be offset in exceptional circumstances (Jaffe *et al.*, 1995; Palmer *et al.*, 1995). In addition, other researchers exploring the determinants for environmental innovation argue that while regulations are necessary to correct market failures (Green *et al.*, 1994), they are often inadequate in dealing with all environmental concerns. As Elliot (1994) maintains: '… the strategies of centralised, bureaucratic control by government, while necessary, will not be sufficient to deal with the plethora of small diffuse sources of pollution that we must control if we are to make continued progress in the years ahead' (p. 1848).

Further, environmental regulations are often seen to hamper innovation in the construction industry (Gann *et al.*, 1998; Manseau and Seaden, 2001; Moe, 2006; Cooke *et al.*, 2007). Gann *et al.* (1998) studied the diffusion of energy efficiency in UK Commercial buildings. Their findings suggest that prescriptive regulations that force organisations to conform to detailed specifications are traditional and stifle creativity. The research of Ryghaug and Sørensen (2009) also highlights the deficiencies in Norwegian public policy in stimulating sustainable energy technologies. The Norwegian energy policy was seen to focus on optimising energy use or reducing energy cost and thus places energy efficiency in the 'iron cage of economics' (p. 986). Manseau and Seaden (2001) also suggest that 'most of currently available public policy instruments in support of innovation have not been of great use to the construction industry' (p. 394).

2. Complex Product Systems (CoPS) Innovation Management Model

The previous section outlined key linear models of innovation processes. In such models, technological change is seen as predominantly an intra-firm problem (Winch, 1998) and is closely related to the production paradigm of mass market commodity goods (Hobday, 1998). The innovating organisation is regarded as a bounded unit of production with coherent boundaries between the organisation's scope of control and the environment with which it interacts (Rosenberg, 1974; Baumol, 2002; Smolny, 2003; Rödiger-Schluga, 2005). However, this conceptualisation of the organisation as a bounded entity is not particularly applicable in the context of organisations where the undertaking of projects forms a large proportion of their general activities (Keegan and Turner, 2000), often called project-based organisations. In such arrangements, the project, defined as 'a temporary endeavour undertaken to create a unique product or service' (PMBOK, 2000, p. 4), will act as the coordination mechanism across the multiple firms involved (Hobday, 1998).

Project-based organisations are an increasingly important unit of economic action and social development in areas of production characterised by high task complexity, interdependency, and immense time constraints (Grabher, 2002; Hobday, 2000). Whether they are called temporary systems (Meyerson *et al.*, 1996), synthetic organisations (Thompson, 1967), project-based enterprises (DeFillippi and Arthur, 1998), cheetah organisations (Engwall and Svensson, 2000), or single-project organisations (Baker and Faulkner, 1991), these forms of organisation are usually active in highly uncertain environments. Such project-based environments are found not only in construction (Eccles, 1981; Gann, 1993) but also in telecommunication (Davies, 1995), advertising (Grabher, 2001), television (Starkey *et al.*, 2000), and film production (Jones, 1996; DeFillippi and Arthur, 1998; Lampel and Shamsie, 2003).

i. Definition of CoPS

While linear models of innovation management have dominated innovation research and influenced innovation research in the construction industry (Winch, 1998), recent research studies have recognised another innovation model particularly associated with project-based organisations. Complex Product Systems (CoPS) Theory predominantly focuses on the relationship between product complexity and the management of innovation. It is based on the premise that as the complexity of a product increases, the dynamics of innovation will largely differ from other types of product, particularly mass-produced relatively simple goods (Hobday, 1998; Walker *et al.*, 1988; Kline, 1990; Hughes, 1983). The term 'complex' is used to represent the large number of integrated and customised components involved, the wide breadth of knowledge and skills required, and the degree of complexity of the knowledge utilised in the design and production of the different product components. Earlier conceptualisation of CoPS is based on studies of industrial organisation (Woodward, 1965), Large Technical Systems (LTS) (Hughes, 1983; 1987), and military systems (Walker *et al.*, 1988) as well as studies on systems complexity (Kline, 1990) and project management (Shenhar, 1994, 1998). Examples of CoPS include telecommunication exchanges (Davies, 1995), flight simulators (Miller *et al.*, 1995), and intelligent buildings (Gann, 1993). Complex product systems are defined by Hobday (1998) as:

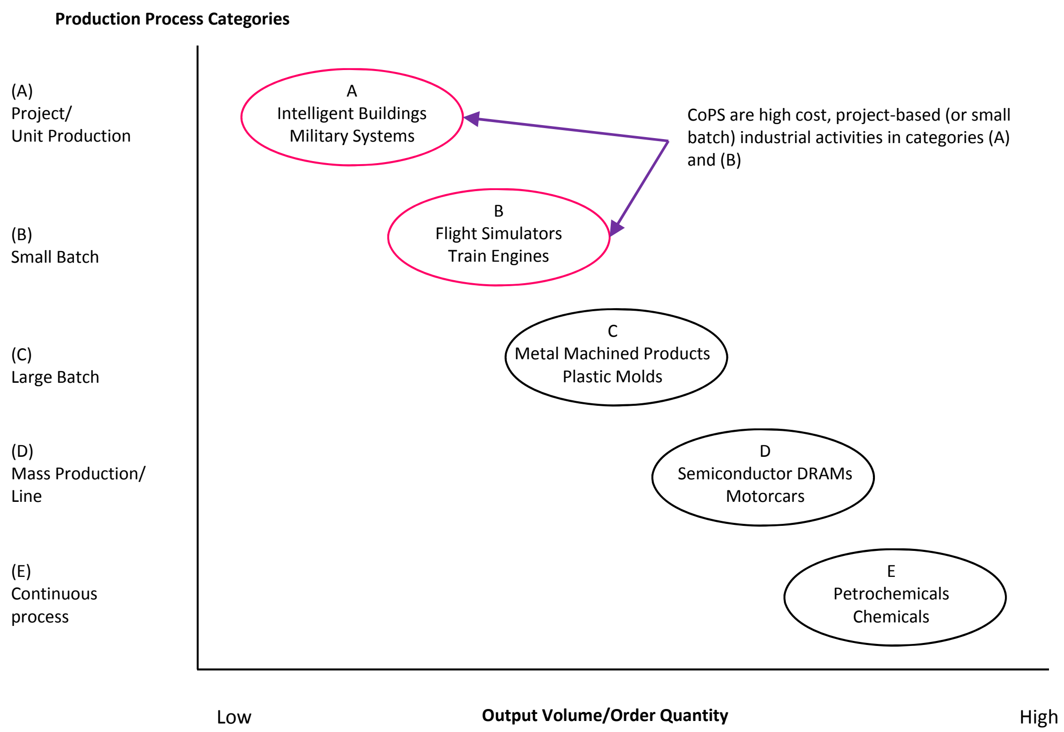
> … Any high cost, engineering-intensive product, sub-system, system or construct supplied by a unit of production, be it a single firm, a production unit, a group of firms or a temporary project-based organisation (Hobday, 1998, p. 2).

Hobday (1998) maintains that CoPS can be differentiated from mass-produced simple goods by four key characteristics that largely influence innovation management processes:

1. They are high-cost hierarchical goods, composed of several bespoke interrelated elements.
2. They are developed in projects including more than one firm and often many cooperating organisations.
3. They often display nonlinear and constantly evolving properties where minor changes to one element of the system can result in large changes in another part of the system.
4. They are characterised by a high degree of client/user involvement to allow their requirements to shape the innovation process, instead of through arms-length market transactions as in linear models of innovation.

In order to illustrate how CoPS relate to the manufacturing and project management paradigms, Hobday (1998) positions them within the traditional industrial categories of Woodward (1958) and Hill (1993) as shown in Figure 2.3.

Figure 2.3: The Scope of Complex Product Systems

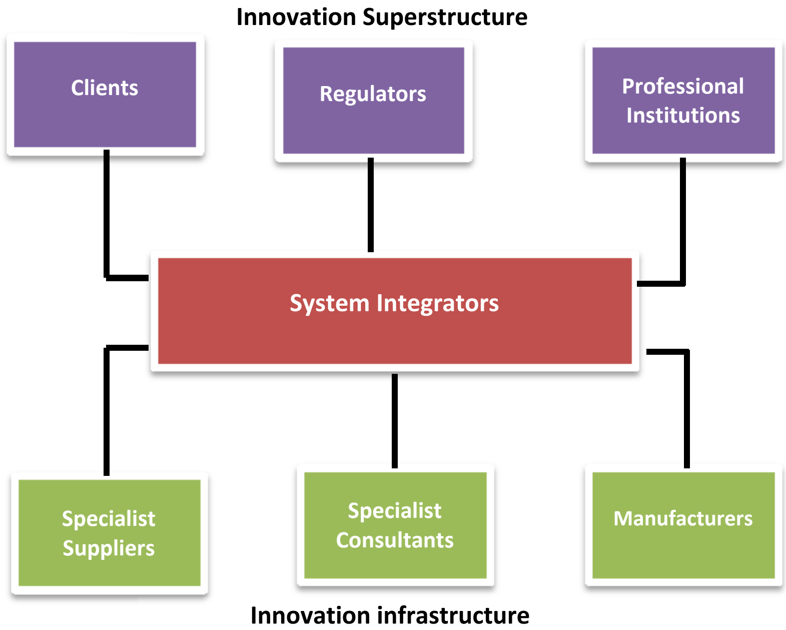


Source: Hobday (1998) adopted from Woodward (1958) and Hill (1993)

Hobday (1998) argues that CoPS could be distinguished from simple products along five dimensions: (1) product life cycles, (2) processes of manufacture, (3) industrial coordination, (4) corporate strategies, and (5) market features. First, CoPS are high-cost, bespoke systems which are never mass-produced and whose operational life cycles extend over decades. Second, their bespoke nature suggests that design development is more important than manufacturing as the main feature of supply. The management of innovation requires the organised contribution of many producers and close client/user involvement and feedback throughout the innovation process. Thus, innovation and diffusion often overlap significantly and cannot be neatly separated, as in mass manufacturing. Third, CoPS are produced through a project management process for a particular customer, representing a well-defined CoPS supply task. In such markets, transactions are infrequent, large in value and long in duration with continuing interactions between clients, users and producers. Fourth, the focus is often on product design and development. The main tasks of producers are system integration and the management of multi-firm alliances in temporary projects (Davies *et al.*, 2007). Fifth, CoPS are often produced in duopolistic and highly institutionalised markets, containing sophisticated price formulas often negotiated for each single transaction. Transactions are few in number, politicised, and regulated (Hobday, 1998).

CoPS are produced in what has been termed *complex systems industries (*Miller *et al.*, 1995). The Complex System Industry Model, as shown in Figure 2.4, was first developed by Miller *et al.* (1995) in the context of the flight simulation industry. Their model distinguishes between the innovation superstructure of clients (airlines), regulators, and professional institutions, and the innovation infrastructure of specialist suppliers and aircraft manufacturers. Managing the interface between the two structures are systems' integrators who provide complete flight simulation systems to airlines for the training of their crews. Indeed, CoPS are often developed within projects which include systems integrators, buyers, suppliers, users and in some cases governmental agencies and regulators. These 'innovation actors' (Winch, 1998) often cooperate in producing CoPS, frequently taking new design decisions and engaging in co-engineering throughout the development process (Miller *et al.*, 1995). Winch (1998) maintains that the complex systems industries model is largely beneficial to innovation research as it provides a clear illustration of the institutional setting in which firms innovate. The model categorises the several types of actor in the innovation network, and distinguishes their specific roles in the innovation process (Winch, 1998).

Figure 2.4: The Complex System Industry Model



Source: Miller *et al.* (1995)

Hobday (1998) stresses the need to consider CoPS as a distinctive analytical category for research purposes. This will advance this arena of research and improve innovation theory beyond the models developed in manufacturing. Hobday (1998) points out that the chief units of analysis for innovation management are:

(a) The project (rather than the single firm as in linear models of innovation), and
(b) Its output (or product) and the links between them.

In this research study, the BSF PFI project is conceptualised as a Complex Product Systems (CoPS) supply network (Hobday, 1998) where innovation success largely depends on the interactive relationships among multiple project participants (Hobday, 1998, 2000; Hobday *et al.*, 2000; Gann and Salter, 2000; Davies and Salter, 2006). Indeed, many authors argue that PFI projects represent CoPS (Barlow and Köberle-Gaiser, 2008ab; Caldwell *et al.*, 2009). PFI projects are complex, high-cost systems tailored to the requirements of a specific buyer (Caldwell *et al.*, 2009). They involve complex long-term interactions among public sector clients/users and private sector producers, spanning multiple decades as the facility is designed, constructed, and used (Howard and Caldwell, 2011). PFI projects often contain complex component interfaces and their development requires the input from multiple skills and knowledge bases. They tend to be produced in markets featuring few buyers and few sellers, a small number of large transactions, and the absence of market prices (Caldwell *et al.*, 2009).

Certainly, the CoPS model of innovation adopted on this research study could be considered as a subset of 'System' approaches to innovation (Freeman, 1987; Freeman and Lundvall, 1988, 1992; Malerba and Orsenigo, 1996; Breschi *et al.*, 2000). In contrast to linear Schumpeterian models of innovation, system-oriented approaches to innovation are founded on the belief that innovation cannot be solely understood in terms of independent decision-making at the level of the firm. Instead, innovation is shaped by complex interactions between a firm and its environment (Freeman, 1987; Lundvall, 1988, 1992; OECD, 1992; Metcalfe, 1995). For example, the 'National Systems of Innovation' model (Freeman, 1987; OECD, 1992; Nelson, 1993; Edquist, 1997) highlights the network of organisations in the private and public sector that interact for the initiation, development and diffusion of new technologies. Another system-oriented model of innovation processes is the 'Sectoral System' approach (Breschi *et al.*, 2000; Malerba and Orsenigo, 1996), which draws attention to the sources and patterns of technological change in different industries, particularly focusing on learning processes and technological opportunities in an industry.

In fact, Edquist and Hommen (1999, 2000) and Rolfstam (2005) suggest that system-oriented theorising is particularly appropriate for evaluating the innovative capacity of public policy instruments; in our case, the capacity of the PFI project delivery model to support SEI within BSF new-build schools. From a system-oriented perspective 'policy is partly a question of supporting interactions in a system that identify existing technical and economic opportunities or create new ones' (McKelvey, 1997, in Edquist and Hommen, 1999 p. 65). The system-oriented perspective clearly acknowledges the complex interdependencies and multiple types of interactions between the various elements of the innovation process (Edquist *et al.*, 2000; Edquist and Hommen, 1999). It is based on the belief that firms 'almost never innovate in isolation' but interact closely with other organisations through complex relations often characterised by reciprocity and feedback loops.

In terms of environmental innovation, Foxon *et al.* (2005) maintain that adequate understanding of systemic processes by which environmental innovation takes place is valuable, both theoretically and to inform policymakers in support of innovative sustainable technologies. Indeed, system dynamics and their role in understanding environmental issues has been the subject of research by evolutionary economists. For example, Kemp and Soete (1992) identified the complexity of industrial systems and the need to view environmental concerns from a systemic perspective. They maintain that economic growth is based on clusters of economically connected technological systems and paradigms. These systems encompass a wide range of elements such as socio-institutional actors, User-Producer relationships, production, marketing, and finance, among others. Kemp and Soete argue, 'As these systems and their corresponding infrastructure develop, negative externalities also occur at increasing rates.' Nelson and Winter (1982) further emphasise that the concept of externalities is dynamic as they maintained that 'the processes of change are continually tossing up new externalities that must be dealt with in some manner or other' (p. 368). Therefore, systemic perspectives to understanding industrial systems, of which construction projects are a major element, is needed if their environmental impacts are to be understood (Irwin and Hooper, 1992; Madu *et al.*, 1995; New *et al.*, 1997; Hall, 2000, 2001).

ii. Determinants of Innovation in CoPS Projects

From stating broadly that CoPS Innovation Management Theory has a superior grasp of the dynamics of innovation in complex project contexts, compared to linear perspectives, this section will proceed to a more detailed examination of specific insights into the underlying forces driving product innovation. Three key determinants of innovation will be outlined, focusing on their significance to understanding innovation success: (a) the client requirement; (b) communication and collaboration; and (c) contractual incentives. These three determinants underline the importance of interdependency and interaction between the different organisations involved within CoPS projects. Particularly, they emphasise the significance of the interactive relationships between the Client/User and the Producer, and within the Producer's supply chain in explaining innovation outcomes. Given the complexity of these theoretical contributions, only aspects of the theory related to this research study are provided. Attempts were also made to simplify and generalise to allow for further development of the subject in the second section, dealing with the concept of innovation as it applies to the project-based construction industry. Readers are advised to refer to key references for further theoretical discussions.

a. The Client Requirement

The nature of the client's requirement is found to play a key role in stimulating innovation in system-oriented approaches to innovation (Pavitt, 1984). As Pavitt (1984) argues, the demand for new products and processes by consumers, public bodies, and other firms is an important determinant of innovation success. In the case of sustainable and environmentally friendly products, the environmental consciousness of clients is a critical success factor (Horbach, 2008). Clients' increasing awareness of the environmental impacts of their purchasing choices can exert significant pressures on service providers to reduce these impacts (Kemp and Foxon, 2007). Clients can also increase the pressure on project participants to improve buildings' lifecycle performance, durability, and future flexibility and adaptability (Gann and Salter, 2000) and demand higher standards and specifications (Barlow, 2000; Seaden and Manseau, 2001).

In CoPS projects, innovation success largely depends on how well the client can define their requirements (Hansen and Rush, 1998), particularly as designs are tailored to their specific needs (Ren and Yeo, 2006). The importance of the client requirement was emphasised by Hobday and Rush (1999) in their study of *hotspots* often confronted by firms producing CoPS. Unclear client/user requirement was identified as a major problem in the path of CoPS innovation (Hansen and Rush, 1998). The degree of regulatory involvement can also shape the process of CoPS innovation. Safety regulations (e.g. in aircraft), interfacing regulations (e.g. in telecommunication), and environmental regulation (e.g. Oil and Gas plants and buildings) can largely influence the path of innovation (Ren and Yeo, 2006).

b. Communication and Collaboration

Communication and collaboration are critical for CoPS innovation (Miller *et al.*, 1995; Hobday, 2000; Brady *et al.*, 2005). Three types of interactive relationships are particularly important: (1) multidisciplinary communication and collaboration, (2) Client-Producer communication and collaboration, and (3) User-Producer communication and collaboration. First, many studies of CoPS have highlighted the importance of effective multidisciplinary communication and collaboration for successful innovation (Miller *et al.*, 1995; Hobday, 2000; Brady *et al.*, 2005). CoPS projects involve a wide breadth of knowledge and skills and thus innovative non-functional organisational structures are necessary. This is particularly important to co-ordinate production as changing user requirements may require feedback loops from later to earlier stages (Hobday *et al.*, 2000). Systems integration and effective coordination capabilities have also been highlighted as prerequisites for innovation (Geyer and Davies, 2000; Davies and Brady, 2000).

Second, the importance of Client-Producer communication and collaboration was emphasised by many studies of CoPS (Miller *et al.*, 1995; Hobday, 1998). Early work by Gardiner and Rothwell (1985) identified the role of the client in aircraft and agricultural machinery innovation and went as far as claiming that the client should be a full 'partner' in the design process. To Gardiner and Rothwell (1985) 'tough customers' stimulate superior designs. Third, User-Producer communication and collaboration was highlighted by various studies (Hobday, 1998; Gardiner and Rothwell, 1985; Rothwell and Gardiner, 1988; Lundvall, 1988; Reich *et al.*, 1996). End users in CoPS projects are often well integrated into the innovation process as products are tailored to fit their requirements (Hobday, 1998). Hobday (1998) argues that innovation processes are User/Producer driven, suggesting that knowledge is co-created (Vargo and Lusch, 2004). The need for face-to-face communication is particularly important when knowledge is 'sticky' (von Hippel, 1994) or very costly to codify, such as in the case of *tacit* knowledge (Thomke and Fujimoto, 2001; Senker and Faulkner, 1993, 1995; Conway, 1997)[1]. The importance of User-Producer communication and collaboration

[1] Knowledge is typically classified as either tacit or explicit. *Tacit* knowledge is non-codified knowledge that is difficult to express, represent, or communicate and is acquired via the informal adoption of learning behaviour and procedures; often referred to as know-how (Polanyi, 1966; Nonaka, 1991, 1994; Nonaka and Takeuchi, 1995). This is distinctly different from more *Explicit* Knowledge which can be codified, recorded, stored, and transmitted via symbols (e.g. writing or drawings) or embedded in a tangible form (e.g. machinery or tools) and effectively applied (Roberts, 2000). To transfer successfully, tacit knowledge requires close communication under conditions of

was also highlighted by complementary system-oriented approaches to innovation, such as von Hippel's (1986, 1998) *Distributed Innovation Process Model.* Contesting traditional models of innovation in which users wait passively for manufacturers to innovate, von Hippel and his colleagues argue that users can contribute actively to product design and may drive the innovation process (von Hippel, 1986, 1998, 2005; Lilien *et al.*, 2002; Lüthje, 2004). Particularly important to the innovation process is the distinct domain of knowledge that producers and users possess. While producers maintain technological and production capabilities, users are knowledgeable about their needs, capabilities, and the context in which the innovation would be used. Due to the 'stickiness' of knowledge in both domains, in that it is difficult to transfer outside of its domain, close involvement of users is needed (von Hippel, 1988, 1998). Another antecedent of system-oriented approaches to innovation is Lundvall's theory of the learning dimension of User-Producer interaction in product innovation (Lundvall, 1988). *Interactive Learning Theory* predicts that markets for complex products would require effective cooperation and exchange of qualitative information and thus may result in users and producers creating dedicated channels and codes of information (Lundvall, 1988).

c. Contractual Incentives

Contracts are in effect a governance mechanism designed to achieve two main goals: to outline the structure of authority-responsibility, and share risk and reward among project partners (Giannoccaro and Pontrandolfo, 2004; Sen and Mitra, 2000). Contracts are safeguarding instruments against opportunistic behaviour, as they establish clear limits for breach of contractual specifications between clients and producers (Liker and Choi, 2004). In CoPS projects, contracts governing the relationships between producers and their upstream clients can range from traditional arms-length contracts to close cooperative relationships.

Mostly, contractual incentives have their theoretical origin defined in the Principal-Agent Theory (Spence and Zeckhauser, 1971; Ross, 1973). The Principal-Agent Theory mainly addresses the relationship between two contracting actors—the Principal and the Agent. The theory is primarily concerned with the difficulties that arise under conditions of imperfect and asymmetric information when a Principal appoints an Agent to pursue the Principal's interests. The theory's central assumption is that both actors will pursue their own objectives. Thus, it assumes that the Agent will

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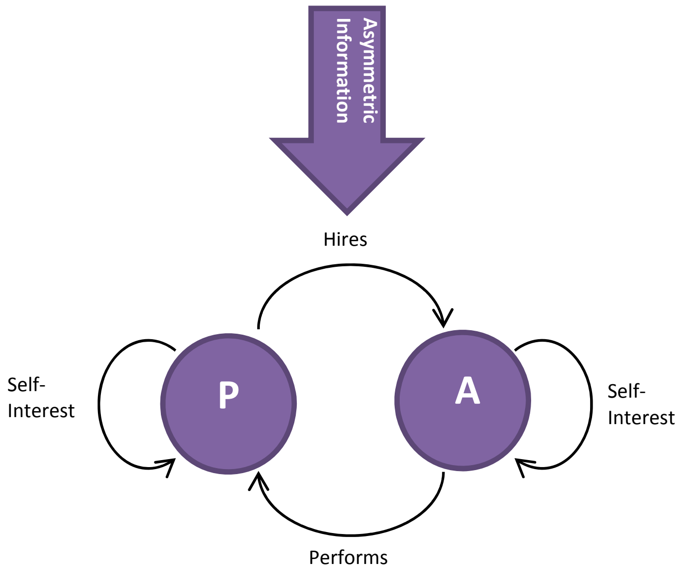
trust (von Hippel, 1994; McAllister, 1995; Zaheer *et al.*, 1998; Edmondson and Moingeon, 1999; Dirks and Ferrin, 2001; Thomke and Fujimoto, 2001; Levin and Cross, 2004).

adopt a strategy with which he will receive the maximum reward for the minimum effort (Milgrom and Roberts, 1992; Douma and Schreuder, 1998; Mumford, 1998). Therefore, incentive-based contracts are designed to align the Agent's objectives with those of the Principal. Figure 2.5 illustrates the Principal-Agent relationship.

Figure 2.5: The Principal-Agent Theory



Source: Milgrom and Roberts (1992)

Two characteristics of contracts are seen to be important for innovation: (1) risk allocation, and (2) reward sharing mechanisms. First, many studies of CoPS projects have emphasised the importance of risk allocation among the contracting parties in determining project success (Hobday, 1998; Miller and Lessard, 2000). Early work by Knight (1921) distinguished between risk and uncertainty, the difference between the two being the ability to measure the probability of future outcomes (Grimsey and Lewis, 2002). While in both cases the various future outcomes are not predictable with certainty, in the case of risk it is possible to assign a value to the probabilities of these outcomes. In the case of uncertainty, the possibility to assign such a value is impossible (Leiringer, 2003). Chapman and Ward (1997) define risk as:

> The implications of the existence of significant uncertainty about the level of project performance achievable (Chapman and Ward, 1997, in Leiringer, 2003, p. 61).

The Treasury Taskforce (TTF, 1999a) also adds that risk includes both potential gain and exposure to loss and therefore can be described as uncertainty as to the amount of benefits. Risk can stem from various factors that might affect the project performance and the risk is said to arise when its impact on project performance is both uncertain and significant (Leiringer, 2003). To Berglund and Hellström (2002) 'risk is a factor in all innovative processes in so far as purposeful, goal-directed action is always directed towards an uncertain future with some possible reward' (Berglund and Hellström, 2002, p. 207). The strategies to identify, allocate and manage those risks depend to a great extent on the type of project, the procurement route adopted, and the contractual arrangements between project participants (Leiringer, 2006).

Risk management is widely considered as one of the most important procedures in the field of project management (Royer, 2000; Turner, 1999). Risk management involves four fundamental processes: risk identification, risk assessment, risk allocation and risk mitigation. To be managed appropriately, risk has to be clearly identified (Akintoye *et al.*, 2001). Following the identification of risk, its significance to project outcome needs to be adequately assessed. The risk assessment process may include reviewing, understanding and determining the importance of all the risks that can impact on the project and estimating the likelihood of their occurrence (Raftery, 1994). The risk impact is often estimated in terms of financial cost or completion time (Raftery, 1994; Arndt, 2000; Akintoye *et al.*, 2001). Risk allocation is the third step in the risk management process. Ideally, risk should be assigned to the party that has the greater ability to influence the probability of occurrence or the degree of consequence of the risk and has the best access to suitable mitigation techniques for the risk (Arndt, 2000). However, as Raftery (1994) noted, this is by no means an easy exercise. In some cases the position of risk in not evident, as risks sometimes cross boundaries and cannot be allocated to a single party (Raftery, 1994). Following the allocation of risk, risk mitigation is concerned with the action taken by an actor to reduce the likelihood of a risk occurring as well as limiting the size of the consequence should the risk occur (Raftery, 1994). There are several risk mitigation strategies such as risk avoidance/ elimination, risk reduction, risk transfer, and risk retention/ absorption (Raftery, 1994). Souitaris (2001) argues that managers of innovative firms are more favourably inclined towards risk acceptance.

The allocation of risk among the contracting parties is an important decision leading to innovation success in CoPS projects (Hobday, 1998; Miller and Lessard, 2000). As CoPS projects are complex, the innovation processes within them are also largely complicated, particularly in relation to the great up-front investments required and the high level of uncertainty, and therefore risk, associated with the success of innovation. Thus, Hobday (1998) maintains that contractual incentives are needed for sharing project risks among clients, users and producers.

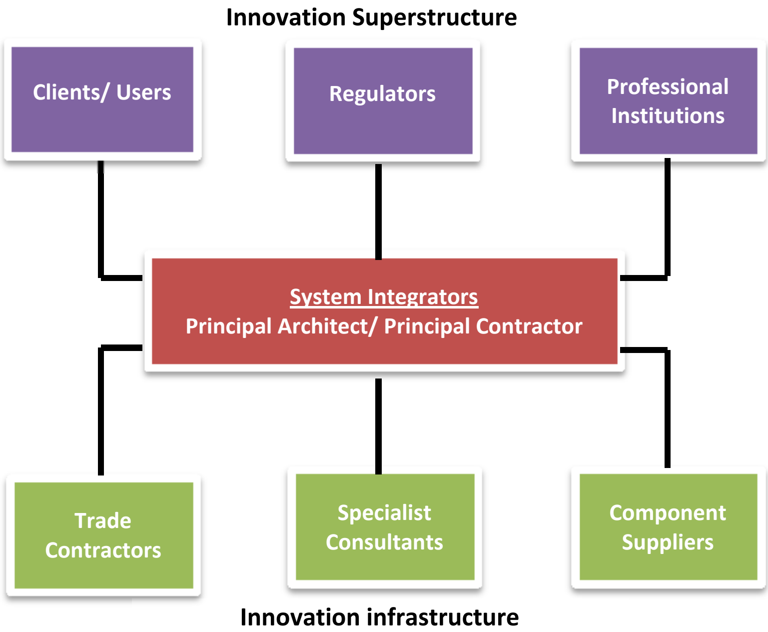
Second, in CoPS projects, contractual mechanisms are needed to enable the reward for innovation to be distributed according to the risk each party has assumed (Miller and Lessard, 2000; Hobday, 1998). As innovation requires the commitment of financial resources to succeed, the reward for innovation must be justifiable for the innovating organisation to commit the risk capital needed (Lazonick and West, 1998). Particularly, Hobday (1998) maintains that clients/users of CoPS need to share the rewards of innovation with producers. Indeed, reward sharing arrangements whereby the benefits from innovation and performance improvement are shared between project participants are seen as key innovation drivers (Barlow, 2000).

2.3 Innovation in the Construction Industry

2.3.1 The CoPS Nature of Construction Projects

The construction industry represents a sector with a high degree of project-based organisations where firms, their suppliers, and customers come together only when there is a project (Atkin, 1999). Indeed, projects by their very definition are 'temporary systems' with 'institutionalized termination' (Lundin and Söderholm, 1995). Each project is unique and complex both in technical and management respects (Wikström, 2000; Mandják and Veres, 1998; House, 1988). The uniqueness and complexity of projects may vary depending on the nature of the facilities or infrastructure solutions to be constructed and, in that sense, projects are unique technically, economically, and organisationally (Owusu, 2003; Slaughter and Shimizu, 2000). In studies of Complex Product Systems (CoPS), authors have pointed out the high-cost, technically intensive, and bespoke nature of construction projects (Hobday, 1998, 2000; Hobday *et al.*, 2000; Gann and Salter, 2000; Davies and Salter, 2006). Indeed, a 'system' perspective to innovation is widely accepted in the construction industry (Blayse and Manley, 2004; Gann and Salter, 1998). Construction innovation is largely seen to incorporate input from a wide range of participants within a 'product system' (Marceau *et al.*, 1999). Early work by Nam and Tatum (1988) examined the main attributes of the constructed product and strongly argued that the constructed product is a complex product system, and that construction is thus a complex systems industry. Adopting the complex systems industries model of Miller *et al.* (1995), Winch (1998) develops a generic model of the structural context of the management of innovation in construction projects as shown in Figure 2.6.

Figure 2.6: Construction as a Complex System Industry



Source: Winch (1998) adapted from Miller *et al.* (1995)

Noting the wide range of participants in the construction industry, Marceau *et al.* (1999) emphasise the need for their close communication and collaboration to achieve innovative outcomes. Indeed, project performance is seldom the responsibility of a single organisation and often depends on the existence of an elaborate body of collective knowledge, bringing together the skills of multiple specialists (Gann and Salter, 2000; Hobday, 1998; Winch, 1998). The project-based organisation is often operational in dynamic multi-technology environments where project success requires organisations to extend beyond their organisational boundaries (Hobday, 1998). Indeed, project performance rests on the effectiveness of technological competencies deployment within and between organisations (Gann and Salter, 2000).

2.3.2 Determinants of Environmental Innovation in Construction Projects

There are increasing pressures on the construction industry worldwide to be innovative to meet growing demands for more sustainable products and processes (Lutzenhiser and Biggart, 2003; Blayse and Manley, 2004; Sørensen, 2005). As Blayse and Manley (2004) emphasise, construction firms must be innovative to compete and win business and survive the global transition to more environmentally friendly products and processes. Dulaimi *et al.* (2003) similarly identify the need for greater exploration of the issues generating a favourable environment for innovation in construction projects. As Bossink (2004) highlights, there are several drivers of construction innovation and these are operational at multiple levels in the network of cooperating organisations, for example: the industry level (Pries and Janszen, 1995), the institutional and firm level (Winch, 1998), and the construction project level (Lampel *et al.*, 1996). In order to emphasise the study's CoPS approach to the study of innovation, determinants of innovation are studied at the construction project level. Particularly, determinants of innovation will be presented in relation to the three determinants of CoPS innovation being: (1) the client requirement; (2) communication and collaboration; and (3) contractual incentives.

1. The Client Requirement

Anderson *et al.* (2004) argue that environmental concerns expressed by a variety of stakeholders are among the chief pressures for change in the construction industry. Indeed, client demand was found to be one of the main determinants of innovation in construction projects (Kumaraswamy and Dulaimi, 2001; Dewick and Miozzo, 2004; Richardson and Lynes, 2007; Hartmann, 2008). The enormous capacity of clients to exert influence towards innovation is well accepted to the extent that 'current policy in the UK identifies the experienced client as the main institutional leader in stimulating construction innovation' (Winch, 1998, p. 276).

Indeed, many studies identified the important role of demand in driving innovation in construction projects (Tatum, 1984; Oluwoye and Lenard, 1999; Blayse and Manley, 2004). Early work by Tatum (1984) explored six innovative construction methods and identified conditions that foster construction innovation. Among the main conditions he distinguishes are challenging engineering, construction, and schedule requirements. Oluwoye and Lenard (1999) also suggest that the level of innovation and the ultimate success of a project highly depend on the client's recognition of the need for technological development and innovation. Nam and Tatum (1997) and Barlow (2000) emphasise that ‘demanding’ clients are likely to stimulate innovation in the projects they commission. Nam and Tatum (1992a) explored the innovations adopted in 10 construction projects and concluded that innovations were stimulated by an innovation-demanding market. Pries and Janszen (1995) reviewed the innovative characteristics of the Dutch construction industry from 1945 to 1995 and argued that while some organisational strategies in the construction industry were traditionally technology-oriented these strategies changed because of the market forces’ driving innovation. Arditi *et al.* (1997) studied the innovation rate in construction equipment in the United States over a period of 30 years and concluded that the innovation rate increased as a result of market forces. Miozzo and Dewick (2002) explored the development of strategic innovations by the largest contractors in Germany, Sweden, Denmark, France, and the UK. One of their main findings was that governments were able to stimulate innovation by guaranteeing markets for innovative products and services. Seaden and Manseau (2001) analysed the national policies of 15 countries in Europe, North and South America, South Africa, and Japan towards innovation in construction. In their findings, innovative demands and specifications by governmental clients were among the main innovation-stimulating policies.

The role of the client requirement in driving innovation is particularly important in the case of sustainable energy innovation. Bossink (2004) examined drivers of environmental and sustainability-related innovation in construction projects. He suggests that innovation is driven by governmental clients with challenging demands guaranteeing markets for innovative firms and subsidising new applications and materials. Oluwoye and Lenard (1999), Graedel (2002) and Beaudoin and Tremblay (2002) equally emphasise the need for sustainability targets as essential prerequisites for the construction of green buildings. Anderson *et al.* (2004) and Richardson and Lynes (2007) similarly suggest that measurable sustainability targets are important drivers for innovation. Indeed, Blayse and Manley (2004) argue that policymakers can force the construction industry to develop new products and technologies by imposing requirements far too difficult for existing technologies to comply with, inducing demand for innovation.

However, limited demand for sustainable energy technologies is one of the main barriers to their adoption in the construction industry. Lovell (2005) highlights what he called the Tenant-Owner dilemma as a barrier to sustainable energy technologies. Often building owners and developers are the least concerned with future energy cost, energy use, and indoor environmental issues, as they are seldom the ultimate users of the building (Hubak, 1998; Ryghaug, 2003, 2005). Their desire to minimise building cost and reduce the risks involved renders the initial investment in improving the energy performance of the building undesirable. To make matters worse, energy standards of the building often weigh less in stipulating rent than other qualities such as location, size, accessibility, and design (Lovell, 2005). To tenants, energy costs often form a small part of the total rent, and long-term price increases have been obscured by unpredictable fluctuations (Ryghaug and Sørensen, 2009). The combination of these two factors means that energy efficiency in buildings is not particularly in demand (Ryghaug and Sørensen, 2009; Intrachooto, 2002).

2. Communication and Collaboration

Three types of interactive relationships are particularly important for innovation: (1) multidisciplinary communication and collaboration, (2) Client-Producer communication and collaboration, and (3) User-Producer communication and collaboration. First, effective multidisciplinary communication and collaboration has long been seen as a necessary prerequisite for successful innovation in the construction industry (e.g. Tatum, 1984; Slaughter, 1993, 1998; Bresnen and Marshall, 2000a; Ben Mahmoud-Jouini, 2000). Indeed, the multidisciplinary nature of the construction industry resulted in communication and collaboration among related parties being of utmost importance (Pektaş and Pultar, 2006). Participants in construction project coalitions often must combine their specialised knowledge from multiple disciplines to create innovative products and services (Sonnenwald, 1996; Dougherty, 1987). Early work by Tatum (1984) argues that establishing effective information flow within the project team is a necessary condition for successful innovation in construction projects. In his study of offshore construction projects, Barlow (2000) also concluded that innovation is facilitated by non-hierarchical internal and external communication structures. Indeed, lateral communication was seen to promote the exchange of knowledge and stimulate creativity (Barlow, 2000). Kangari and Miyatake (1997) described factors that contribute to developing innovative construction technologies in Japan. One of the factors they highlighted was construction technology 'fusion', which is the integration of diverse technologies from various disciplines to develop innovative construction techniques and processes. Tatum (1989) also reported that the coordination of all participating groups in the innovation process is an important innovation driver.

Effective communication and collaboration is nowhere more needed than in the development of sustainable buildings (Rohracher, 2001; Anderson *et al.*, 2004; Intrachooto and Horayangkura, 2007).

Intrachooto and Horayangkura (2007) emphasise the need for designers, engineers, and other consultants to work collaboratively in order to introduce innovative environmentally sound technologies into building systems, without jeopardising construction budgets. As Rohracher (2001) emphasises, sustainable buildings demand high-tech components, which are supplied by specialised companies. This may include technologies such as solar heating, heat recovery, and transparent insulation materials. Hence, different types of services and consultancy become important as high levels of expertise are needed to deal with the complex problems of ecological optimisation. Therefore, more intensive cooperation between those specialised actors is necessary (Rohracher, 2001). Anderson *et al.* (2004) also point out that few actors in the conventional construction industry have enough expertise for setting up sustainable energy technologies. This is because implementing novel heating, ventilation, and air-conditioning technologies (HVAC) calls for the collaboration among diverse materials and construction suppliers. Specifically constructed consortia which are able to coordinate the entire building process are needed, such as in the case of the 'smart house' (Lutzenhiser, 1994). Less formalised collaboration falls short in distributing innovation benefits evenly to the construction project actors (Anderson *et al.*, 2004). Dewick and Miozzo (2004) assessed how sustainable technologies in the Scottish social housing sector are introduced and diffused. They observed that long-term relationships, combined with alternative procurement forms, helped overcome conservative tendencies, increased trust between the parties, and encouraged the adoption of new technologies. They also identified that innovation is driven by the involvement of the project coalition, particularly architects and contractors, at an early stage in the construction process.

Second, Client-Producer communication and collaboration is also seen to be critical in achieving sustainable energy objectives and reducing CO_2 emissions (Ornetzeder and Rohracher, 2006; Heiskanen and Lovio, 2007). Rohracher (2001) emphasises that on highly efficient green buildings the functional dependency and complexity of the different components highly increases, and in some cases, such buildings become more 'machine-like'. Therefore, these buildings can only be successfully constructed through closer interaction among suppliers, professionals, clients, and users (Rohracher, 2001). Increased client awareness and environmental responsibility may create a sense of ownership in the design team and reduce financial barriers by legitimising a less rigid budget to support innovation development (Intrachooto and Horayangkura, 2007). Intrachooto and Horayangkura (2007) maintain that since clients will ultimately finance most of the cost of the innovation, their clear appreciation of the 'value' of the technological development is paramount. A clear client 'vision' and commitment to energy efficiency was found to be particularly important in the implementation of energy-efficient innovation (Intrachooto and Horayangkura, 2007). Richardson and Lynes (2007) explored the barriers and motivations to green buildings at a university campus. Their findings suggest that one of the main ingredients for success is clients' internal leadership through a committed project champion with an open attitude to creative design. Bossink (2004) identified factors that drive environmental innovation in construction project networks. Among the key drivers identified are effective information-gathering, lateral communication structures, boundary-spanning activities between clients, designers, builders and suppliers, and empowerment of innovation champions and leaders.

Third, User-Producer communication and collaboration is seen as a key ingredient for the successful implementation of any sustainability or environmental initiative on projects (Barraclough, 1990; Paavola and Adger, 2002; Kaatz, *et al.*, 2005; Rohracher, 2003, 2005). It was also found to be critical in realising sustainable energy objectives and reducing carbon emissions (Ornetzeder and Rohracher, 2006; Heiskanen and Lovio, 2007). In Richardson and Lynes's examination (2007) of barriers and motivations to green buildings at a university campus, their findings suggest that the successful implementation of green buildings needed financial vision and collaboration between designers and end users. In fact, some commentators argue challengingly that the wider adoption of environmental technologies may not actually result in overall improvements in environmental quality (Herring and Roy, 2007). Herring and Roy (2007) suggest that cost-saving energy technologies may initiate and support increases in real wealth, which translates into additional consumption, associated emissions, and resource use. This was termed the *rebound effect* by Herring and Roy, (2007) who argue that energy efficiency improvements that lower the implicit price of energy often lead to greater consumption. Therefore, user involvement is particularly important in determining users' commitment to energy efficiency and their 'readiness for change' (Clement *et al.*, 2009).

3. Contractual Incentives

Lenard and Eckersley (1997) and Oluwoye and Lenard (1999) suggest that the level of innovation that occurs on construction projects is highly dependent on contractual incentives to encourage innovation. Contractual incentives are often said to encourage superior economic performance (Bayliss *et al.*, 2004; Tang *et al.*, 2006), time performance (Chua *et al.*, 1999), quality (Koehn and Datta, 2003), innovation (Dulaimi *et al.*, 2003; Caldwell *et al.*, 2009) and improved overall project performance (Bresnen and Marshall, 2000b; Tang *et al.*, 2006; Eriksson and Westerberg, 2010).

The need for effective contractual incentives is particularly important for environmental innovation due to the high levels of risk associated with the development of such technologies. In fact, financial risk and uncertainty are major barriers to the development of sustainable energy technologies in the construction industry (Intrachooto and Horayangkura, 2007). This is largely due to the newness of the technology, the immature market structure supporting it, and the frequent preference for tried and tested solutions by developers. Also adding to the financial risk are the longer design development time needed to develop energy-efficient buildings and the lack of industry-wide benchmarks that identify the relationship between investment amount and energy efficiency (Intrachooto and Horayangkura, 2007). Moreover, the budget assigned for the design process generally lacks financial compensation and incentives for designers to develop innovative solutions. Conventional design practices are often based on meeting the client's requirement with limited intellectual agenda, leading to generalised budget allocation and structure and inability to foresee scientific and technological difficulties and demands of technological innovative design (Intrachooto and Horayangkura, 2007). Indeed, scientific or engineering analysis and evaluation are seldom covered by the project budget. This is particularly the case when profitability is considered the top priority rather than the exploration of alternative developments (Intrachooto and Horayangkura, 2007). The contract and legal systems in the construction industry may also inhibit innovation. Barlow (2000) argues that the risks associated with construction projects are often managed by cascading legal contracts that pass risk down the supply chain (Anderson *et al.*, 2004). This, however, places pressure on the parties involved for tried and tested approaches, severely diminishing their ability and willingness to be innovative (Chesborough and Teece, 1996; Jaffe *et al.*, 2002).

In addition to the barriers brought in by construction industry relationships, the nature of SEI may introduce additional risks associated with their development and implementation. SEI generally entails higher up-front or start-up costs compared to traditional solutions. For example, according to the United States Department of Energy (2005), the most commonly used fuel cells cost approximately US$ 4,500 per kilowatt, whereas a diesel generator costs less than US$ 1,500 per kilowatt, and a generator run on natural gas may cost even less (Intrachooto and Horayangkura, 2007). Innovative sustainable energy solutions also often affect multiple components and require higher overall investment (Intrachooto and Horayangkura, 2007). For example, improving the insulation performance of external walls or introducing natural ventilation to minimise reliance on mechanical equipment will directly influence the building structure, acoustic performance, and construction programme. This ultimately impacts on construction cost and financial risk (Intrachooto and Horayangkura, 2007).

Furthermore, energy efficiency, unlike most technical innovations in buildings, implies future financial saving and returns by reducing the cost of building operation (Intrachooto and Horayangkura, 2007). However, a payback period is required in order to realise the maximum financial benefits from energy efficiency technologies. This payback period is heavily influenced by estimates of potential gains in saving and by prospective reductions in capital investment. Payback periods can, therefore, positively influence the attractiveness of energy efficiency investments, provided the expected savings in operational costs outweighs the high initial capital investment. Consequently, decisions to implement SEI are often difficult because they largely depend on estimates of future performance, which cannot possibly predict all variables or guarantee savings (Intrachooto and Horayangkura, 2007). The long-term commitment and extended payback period required to realise maximum savings from the implementation of some sustainable energy technologies provide limited incentive for clients to include them in their developments (Cooke *et al.*, 2007). For example, Photovoltaic panels (PVs) used in the facade of Four Times Square Office Tower in New York City require about 25–30 years payback period (Storey, 2005). The long payback period is particularly inhibiting when owners are not the ultimate occupiers of the building and thus not the direct beneficiaries of such technologies (Intrachooto and Horayangkura, 2007).

2.4 Summary

The purpose of this Chapter was to identify key determinants of SEI postulated in Innovation Management Theory. One of the fundamental points of departure for this study is the understanding of innovation as 'the actual use of a nontrivial change in a process, product or system that is novel to the institution developing the change' (Freeman, 1989, p. 11). The study also adopts a Complex Product Systems (CoPS) perspective to SEI in which innovation success largely depends on the dynamic, collective and interactive relationships among multiple project participants (Hobday, 1998, 2000; Hobday *et al.*, 2000; Gann and Salter, 2000; Davies and Salter, 2006). The Chapter outlined three key determinants of innovation in complex projects, focusing on their significance to understanding innovation success. First, in CoPS projects, innovation success largely depends on how well the client can define their requirements (Hansen and Rush, 1998). Indeed, the nature of the *client's requirement* is found to play a key role in stimulating innovation in system-oriented approaches to innovation (Pavitt, 1984). As Pavitt (1984) argues, the demand for new products and processes by consumers, public bodies, and other firms is an important determinant of innovation success. Second, many studies of CoPS have highlighted the importance of effective *communication* *and collaboration* for successful innovation (Miller *et al.*, 1995; Hobday, 2000; Brady *et al.*, 2005). In CoPS projects, innovative non-functional organisational structures are necessary to co-ordinate production as changing user requirements may require feedback loops from later to earlier stages (Hobday *et al.*, 2000). The importance of client and user involvement for successful product innovation was also identified by several studies in CoPS innovation (Miller *et al.*, 1995; Hobday, 1998). Clients and users in CoPS projects are often well integrated into the innovation process as products are custom-made to fit their requirements (Hobday, 1998). Third, *contractual incentives,* particularly risk and reward sharing arrangements, whereby the benefits from innovation and performance improvement are shared between project participants are seen as key innovation drivers (Miller and Lessard, 2000; Hobday, 1998).

Attention was then focused on the project-based construction industry and determinants of SEI were explored. First, *the client requirement* is seen as an important driver for SEI in construction projects. Innovation is stimulated by clients' recognising the need for innovation through challenging sustainability, engineering, construction, and schedule requirements, standards, and regulations (Anderson *et al.*, 2004; Oluwoye and Lenard, 1999; Richardson and Lynes, 2007). Second, *communication and collaboration* is particularly important for sustainable buildings, as a high level of expertise is needed to deal with the complex problems of ecological optimisation (Rohracher, 2001; Anderson *et al.*, 2004; Intrachooto and Horayangkura, 2007). Client and user involvement is seen to be critical in achieving sustainable energy objectives and reducing CO_2 emissions (Ornetzeder and Rohracher, 2006; Heiskanen and Lovio, 2007). Third, *contractual incentives* are needed for environmental innovation due to the high levels of risk associated with the development of such technologies (Bossink, 2004; Intrachooto and Horayangkura, 2007).

In conclusion, this theoretical legacy, combining different but complementary theoretical views from CoPS Innovation Theory, as well as construction-specific innovation studies, indicate that a CoPS approach is particularly useful for understanding the innovative capacity of the PFI project delivery model. Synthesis of these theoretical contributions may emphasise the importance of three project-level determinants for SEI success:

1. Clarity of the requirement (Hansen and Rush, 1998; Hobday and Rush, 1999; Ren and Yeo, 2006).
2. Communication and collaboration:

i. Producers' multidisciplinary communication and collaboration (Miller *et al.*, 1995; Hobday, 2000; Brady *et al.*, 2005).

ii. Client-Producer communication and collaboration (Gardiner and Rothwell; 1985; Miller *et al.*, 1995; Hobday, 1998).

iii. User-Producer communication and collaboration (Hobday, 1998; von Hippel, 1988; 1998; Lundvall; 1988).

3. Contractual incentives:

    i. Risk allocation (Hobday, 1998; Miller and Lessard, 2000).

    ii. Reward sharing mechanisms (Hobday, 1998; Miller and Lessard, 2000).

In order to develop further understanding of the BSF PFI context, the next Chapter will examine the BSF PFI project delivery model, identifying the key characteristics that distinguish the procurement strategy from other forms of procurement.

Chapter 3: The Private Finance Initiative (PFI)

3.1 Introduction

Understanding the BSF PFI project delivery model and how projects are structured is important for considering the implications for Sustainable Energy Innovation (SEI). To fulfil the research objectives, the second step should be to understand fully the study's context. Therefore, this Chapter provides a thorough understanding of PFI as a delivery model for new-build school buildings within the context of BSF. The Chapter will start by defining PFI as a form of Public Private Partnership (PPP). PPP and PFI will be defined and the motivation for their adoption explained. The next step is to examine the delivery model of BSF projects, outlining the main contractual actors and development stages. Finally, the key BSF PFI characteristics that distinguish the project delivery model from more traditional approaches will be identified.

3.2 The BSF PFI Project Delivery Model

3.2.1 Definition of PFI Projects as a form of PPP

A Public Private Partnership (PPP) is a durable cooperative venture between the public and private sectors built on the expertise of each partner, which best meets clearly defined public needs (Allan, 1999; Pierce and Little, 2002; Webb and Pulle, 2002; Klijn and Teisman, 2002; Akintoye *et al.*, 2003). Klijn and Teisman (2002) define a PPP as:

> Cooperation between public and private actors with a durable character in which actors develop mutual products and/or services and in which risk, costs, and benefits are shared (Klijn and Teisman, 2002, p. 2).

The PPP project delivery models encompass an array of possible relationships among public and private entities for infrastructure development. Each PPP involves private resources being utilised to provide a public service. This service can range from Operate and Maintain (O&M) contracts in which the facility is completely owned by a public body but is being operated and maintained by a private firm, to Build, Own and Operate (BOO) contracts where the private sector firm builds a public facility, operates it on behalf of the public body, and continues to own the facility in perpetuity. Table 3.1, adopted from Gunnigan (2007), summarises the main types of PPP projects.

Table 3.1: Types of PPP Projects

Type	Description	Transfer of title	Duration of Partnership
Operate and Maintain (O&M)	Private sector organisation enters contract to operate a public sector facility on behalf of a public sector organisation over an agreed period of time.	Remains with public sector organisation for duration of the contract	For duration of contract
Design & Build (D&B)	Private sector organisation enters contract to design, build, and provide construction finance for a public sector project. Public sector organisation pays agreed contract sum on completion of the construction phase.	On completion of construction	On transfer of title
Build Lease Transfer (BLT)	Similar to D&B except that the public sector organisation pays for the project over a long-term lease.	On completion of payment of lease	On transfer of title
Design Build Finance Operate (DBFO)	Private sector organisation enters contract to design, build, finance, and operate a public sector facility over an agreed period. Private sector organisation recovers its investment over the contract period through payments by the public sector organisation for services delivered.	Remains with public sector organisation for the duration of the contract	For duration of the contract
Build Operate Transfer (BOT)	Private sector organisation enters concession contract to design, build, finance, and operate a public sector facility over an agreed period. Private sector organisation recovers investment over the contract period under the pre-negotiated contract terms. The concession period is usually significantly shorter than the operating life of the facility.	At the end of the contract period	On transfer of title
Build Own Operate (BOO)	Private sector organisation enters concession contract to design, build, finance, and operate a public sector facility for as long as the economic operating life of the facility.	Remains with public sector organisation in perpetuity	For duration of the contract

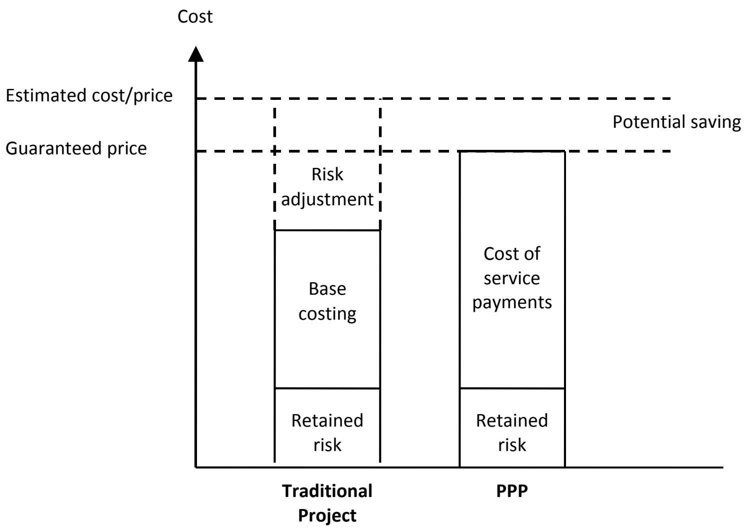
Source: Gunnigan (2007)

PFI is a specific type of PPP. In a PFI project, a consortium of private sector firms assumes the responsibility of designing, building, financing, and operating an infrastructure facility. Public services are provided by the PFI consortium on a long-term contractual basis (often 25–30 years) with the relevant governmental body. The PFI contract is structured so that the private consortium of firms is guaranteed a full return on costs, including interest on the capital borrowed, as well as a return on their investment (Grout, 1997).

In the UK, PFI was introduced in 1992 by the then Conservative government as a means to exert tighter control on public expenditure to curb inflation (Kee and Forrer, 2008). The delivery model was seen as an innovative way of financing public infrastructure by encouraging private capital to invest in infrastructure projects such as roads, housing, hospitals, and schools. A further motivation was the belief in the ability of the private sector to deliver better value for money and achieve greater efficiency (HM Treasury, 1996). While in opposition, the Labour Party was strongly opposed to PFI. However, once in government in 1997 they adopted it with enthusiasm (Kee and Forrer, 2008). Indeed one of the first reports on PFI produced by the Labour government refers to it as: 'One of the main mechanisms through which the public sector can secure improved Value-for-Money [VfM] in partnership with the private sector' (HM Treasury Taskforce, 1998b, p. 2).

There are two fundamental reasons that motivate governments to enter into PFI arrangements for infrastructure development: to draw private capital investment (often to either complement public resources or free them for other public needs) and to increase the efficiency and effectiveness of available resources (ADB, 2007). Firstly, governments are often challenged by a growing need to find sufficient funding to develop and maintain the infrastructure necessary to support growing populations. Governments are faced with the needs for increasing urbanisation, rehabilitating aging infrastructures, expanding networks to new populations, and reaching previously neglected or marginalised areas. In addition, Infrastructure services are often provided at an operating deficit, which is only met through subsidies, thus resulting in an increased drain on public resources (ADB, 2007). Coupled with most governments' limited financial capacity, these pressures motivate governments to mobilise private sector capital for infrastructure investment (ADB, 2007). In addition, under PFI projects, private finance is used to provide and improve public services rather than to acquire capital assets (Gunnigan, 2007). Indeed, public sector actors adopting this project delivery model are said to value the 'in-use value' of the building over the 'bricks and mortar' construction (Caldwell *et al.*, 2009; Lewis and Roehrich, 2009). PFI projects are often dealt with as 'off-balance sheet' projects, thereby not influencing public sector borrowing requirement (Broadbent and Laughlin, 2002). Secondly, the efficient use of rare public resources is a critical challenge for governments, and one in which many governments fail to reach their goals (ADB, 2007). This is because the public sector often has little or no incentives for efficiency built into its organisation and processes and is, therefore, poorly positioned to procure and develop infrastructure efficiently (ADB, 2007). In fact, a major driver for the adoption of PFI models in the public sector is the belief that they offer better Value-for-Money (VfM) than traditionally procured projects.

Figure 3.1: Potential Savings through Risk Transfer



Source: HM Treasury (1999)

In the UK, the VfM assessment for PFI projects is undertaken by using a Public Sector Comparator (PSC), which establishes costs over the operation of the service both through traditional procurement methods and through PFI. Those that show better value by using PFI are endorsed. VfM is defined as 'the optimum combination of whole life costs and quality (or fitness for purpose) to meet user requirements' (HM Treasury, 2003a, p. 30). The calculation of better value is often seen to be drawn from the valuation of risks transferred from the public to the private sector (CIC, 2000). The Construction Industry Council (CIC) examined cost-saving and innovation in PFI projects and determined that 29 out of the 67 projects examined depended entirely on risk transfer to achieve VfM (CIC, 2000). An important conclusion drawn from the CIC (2000) study was that the risk of construction cost overruns attracted the highest valuation from the public sector. The value of risk transfer was seen by the public sector to increase the predictability of projects' outcome and improve the ability to gain earlier certainty on the out-turn value and cost of the projects (CIC, 2000). Therefore, the value of risk transfer is to be understood as the difference between a guaranteed price and the otherwise estimated cost/price (CIC, 2000). However, Gallimore *et al.*

(1997) point out that the price of this risk transfer can be high and that VfM criteria could dictate the level of risk transferred. As Gunnigan (2007) highlights, risk and finance are largely interwoven.

The use of Public Sector Comparators (PSC), however, has been the subject of considerable international debate over their reliability, accuracy, and relevance to the contexts in which they are being used (Bloomfield *et al.*, 1998; Walker and Walker, 2000; Pollock *et al.*, 2002). In the UK, the House of Commons' 2003 report identified a number of cases where the desire to show that PFI deals are 'cheaper' than the PSC, or make projects more 'PFI-able' (Hodge and Greve, 2010) has led to manipulation of the underlying calculations and erroneous interpretation of the results (House of Commons, 2003). Indeed, the issue of defective estimates of costs and benefits is the subject of many studies that see drivers of budget and schedule overruns as either exogenous to the project organisation, such as unexpected events, stakeholders' actions, or regulatory restrictions (Miller and Lessard, 2000; Hughes, 1998; Stinchcombe and Heimer, 1985; Shapira and Berndt, 1997) or rather endogenous factors such as the strategic misrepresentation of the business case by project promoters so as to alter resource allocation in their favour (Flyvbjerg *et al.*, 2002, 2003, 2005). The accuracy of the PSCs is also questionable as they are prone to error as a result of the complexity of the financial modelling used and their dependence on uncertain forecasts (Kahnemann and Lovallo, 1993; Buehler *et al.,* 2002; HM Treasury, 2003b; Winch, 2008). PSCs are also seen to be weak in considering qualitative and non-financial differences between options (Monbiot, 2002; Greve, 2003; Shaoul, 2004).

3.2.2 PFI in New-build BSF Schools

The DfES conducted an analysis of VfM for its use of local government PFI credits in BSF, which comprised both quantitative and qualitative assessments (DfES, 2005a). The quantitative assessment considered how the quantifiable costs and benefits of using PFI as the project delivery model in BSF are likely to compare with conventional procurement (both within BSF and with other schools programmes). The results showed that the decision to allocate PFI credits to 'new-build' schools represented good VfM. A new-build school is defined as that in which the new-build element exceeds 70% of the school's area (DfES, 2005a). DfES (2005a) also conducted a qualitative assessment which considered the viability, desirability, and achievability of using PFI in BSF, when assessed against alternative procurement routes. The results came favourable to the use of PFI and identified three distinctive benefits: better risk management, increased innovation, and reduced bid cost.

First, the DfES supported its argument that PFI will provide better risk management by referring to previous research on non-PFI construction projects which has shown that almost 70% of conventional construction projects came in late and 73% came in over budget (NAO, 2001). On the other hand, comparative figures for PFI from both NAO (2001) and HM Treasury (2003a) showed that almost 90% of PFI projects were delivered on time and the public sector bore no financial costs due to delay. Where cost to the public sector increased, this was largely due to changes in public sector requirement and not to construction overruns. Therefore, it was hoped that PFI would introduce greater risk management in the delivery of new-build BSF schools.

Second, the DfES (2005a) considered from the outset that there was great scope for innovation because of the new approach to capital investment being introduced by BSF. The DfES (2005a) believed that innovation on BSF will stem from three main areas: educational provision, school design, and procurement. Education innovation was seen to come from the opportunity for local authorities, schools, and communities to consider their education visions for the entire area. The scale of area-wide buildings investment was seen as an opportunity to promote reform of the secondary education system and deliver modern and sustainable schools with adequate facilities to promote high-quality learning (DfES, 2005a). The second area of potential innovation was school design. The aspiration was for schools to be designed to meet the needs of pupils and teachers in the 21st Century, raise educational standards, and improve the quality of life within a school (DfES, 2005a). To support innovative design, the DfES developed 'exemplar design' models for school buildings in collaboration with leading architectural practices to put in place benchmark standards and encourage creativity (DfES, 2003b). The third area of potential innovation is procurement, launched by introducing the innovative joint venture model of the Local Education Partnership (LEP). The LEP was a joint venture between a suitable Private Sector Partner, the Local Authority, and Partnership for Schools (PfS), the public body responsible for managing the programme (DfES, 2004c). The continuous involvement of the LEP was hoped to increase standardisation and streamline the supply chain (DfES, 2005a).

Third, another reason for PPPs, and in particular the LEP model, was to reduce the cost of bidding to the industry (DfES, 2005a). The BSF initial competitive procurement process included only a few 'representative' or 'sample' schools to speed up procurement and save public and private sector bid costs. Detailed proposals for the remaining schools were developed after the contract was signed with the Private Sector Partner. The DfES (2005a) argued that an estimated £0.5 billion of bid cost efficiencies was to be achieved over the life of the programme through providing exclusivity beyond the initial competition to be the LEP partner. This exclusivity was hoped to allow the Private Sector Partner to adopt a more strategic and comprehensive perspective to the ‘portfolio’ of projects (DfES, 2005a). While this was the objective, however, BSF projects were later criticised for their high costs, particularly bidding costs assumed by the industry. On one occasion, the cost of an unsuccessful BSF bid reached £5m (Skanska PLC’s unsuccessful bid for the £600m Kent BSF) (Building, 2008). The high costs were understood to be owing to the amount of design work the company had to prepare as it employed five architectural firms to prepare seven sample school designs (Building, 2008).

3.3 Main Contractual Parties on a BSF PFI Projects

This section will outline the main public and private sector actors that come together to form the BSF Local Education Partnership (LEP) and PFI agreement.

3.3.1 Public Sector Actors

i. The Local Authority

Local authorities were introduced to BSF in waves, based on need. The Local Authority is the principal client for all building, ICT, and facilities contracts. Local authorities had an important role to play in BSF, given their statutory responsibilities and the strategic and financial flexibility they have through the Single Capital Pot and the new prudential regime (PfS, 2008). In schools provided through PFI, once the contract is signed the Local Authority receives financial support from the government through revenue support towards the cost of the contract. However, this contribution, although significant, was intended to cover only that portion of the Unitary Charge in relation to the repayment of capital and life-cycle maintenance. The Local Authority, therefore, needed to cover the balance of the charge, often called the ‘Affordability Gap’ or an increase to the Local Authority’s contribution (PfS, 2008). The Local Authority needed to develop local strategies for how the investment will be used before procuring the LEP. The Local Authority also held a minority shareholding in the LEP alongside Building Schools for the Future Investments (BSFI) and the Private

Sector Partner. The Local Authority was also often supported by several internal and external consultants and advisors such as design champions (CABE, 2007a), CABE enablers (CABE, 2007b), and Client Design Advisors (CABE/RIBA, 2005).

ii. Schools

The BSF process commences with the Local Authority deciding on its ‘sample’ schemes (PfS, 2008). Sample Schools are 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 of sample schools developed during the procurement process formed a significant part of the evaluation process to select the Private Sector Partner. Subsequent school projects were to be delivered by the LEP after the award of the contract. Schools delivered under the PFI model needed to adapt to new ways of performing (PfS, 2008). First, schools needed to agree to pay the Local Authority from their delegated budget the proportion of the Unitary Charge that relates to the operation and management of the school facilities, such as maintenance and cleaning. This is the subject of a binding Authority-Governors Agreement. In addition, in a school provided through PFI, the Head Teacher is no longer directly responsible for many aspects of the school buildings. These responsibilities are transferred to the ProjectCo Special Purpose Vehicle (SPV), which has a contract with the Local Authority rather than directly with the school. The ProjectCo SPV delivers the serviced accommodation to an agreed service standard to the school. It was hoped this would ease the load on School management and enable it to concentrate on delivering the curriculum and on improving educational achievement (DfES, 2005a).

iii. Governmental Bodies

a. The Department for Children, Schools, and Families (DCSF)

The DCSF, formerly known as the Department for Education and Skills (DfES) is the government department that owns and has overall responsibility for BSF and the Academies Programme. The DCSF changed to the Department for Education (DfE) in May 2010.

b. Partnerships for Schools (PfS)

Partnerships for Schools (PfS) is a non-departmental public body (NDPB) and a joint venture between DCSF and Partnerships UK (PUK). PfS' role is to manage the delivery of the programme of strategic investment and work with local authorities and schools to organise a steady supply of groupings of schools which need strategic renewal, with funding arrangements in place. An important role of PfS is to make sure local authorities have the needed capability and capacity in place before they enter the procurement stage (DfES, 2005a).

c. Partnerships UK (PUK)

PUK was set up by the government to speed up the development, procurement, and implementation of Public Private Partnerships (PPPs). PUK works exclusively with and for the public sector. It is 44% owned by HM Treasury and 5% owned by Scottish Ministers. PUK assumes a stake in both Partnerships for Schools (PfS) and BSFI.

d. Building Schools for the Future Investments (BSFI)

BSFI is a limited liability company jointly funded by the DCSF, PUK, and PfS. BSFI carries out and manages the central investment in LEPs and their initial PFI projects, assuming a minority stake in each LEP established, along with the Local Authority and their Private Sector Partner. Once an LEP has been set up, BSFI sits on the LEP and PFI SPV boards to help drive the partnership between the public and private sectors.

3.3.2 Private Sector Actors

i. The ProjectCo

The *ProjectCo* is a group of private sector actors who come together to bid for and later to implement a PFI project. The type of actors that are included in a ProjectCo depends on the skills needed to undertake the project (CIC, 1998). In a BSF PFI project, the key ProjectCo actors usually include an investment company (InvestCo), a contractor, architects, building service engineers, structural engineers, service providers, and financiers. An InvestCo is a term used to refer to a company that bids for and invests equity in PFI projects. Usually, an InvestCo is a subsidiary of a large construction organisation. In addition, at various stages of project development the ProjectCo may include a wide range of consultants, building subcontractors, and service providers (Rintala, 2004).

At the beginning of the BSF development process, the ProjectCo actors come together to bid for a BSF project with the aim of securing two contracts. The first is the Strategic Partnering Agreement (SPA) between the Local Authority and the LEP, formed through a Shareholder Agreement (SHA) between the Private Sector Partner (PSP) (80%), the Local Authority (10%) and BSFI (10%). They also aim to secure the DBFO contract to undertake the PFI element. The ProjectCo utilises a Special Purpose Vehicle (SPV), owned by the InvestCo, to enter into the DBFO contract with the Local Authority. The SPV is formed just prior to Financial Close for the sole purpose of implementing the project. The SPV finances the large majority of project development and implementation until the project has become operational using project finance. Project finance is secured against the revenue, namely the Unitary Payment the SPV will receive from the Local Authority for providing the service (CIC, 1998).

ii. The Building Contractor

The Building Contractor will usually be responsible for designing and building the asset under a design and build contract (D&B). Depending on the size and scope of the project, the Building Contractor could be either a single company that undertakes the work by itself, with or without the appointment of designers, or a consortium of construction and design companies, such as architects, service engineers, and structural engineers. It is common that the Building Contractor also has a stake in the ProjectCo.

iii. Facility Managers/Operators

The Operator is usually part of the ProjectCo. Operation is normally divided into soft and hard services and it is not unusual that the Operator has one or several subcontractors.

iv. Suppliers

The role of suppliers is dependent on the needed service and the characteristics of the built asset. It is not unusual for suppliers of major components or large technology owners to take a part in the ProjectCo.

v. Equity Providers and Debt Financiers

Arndt (2000) argues that equity providers of a project are the owners of the project. Equity is classified as the lowest form of capital in a project and the demands of equity investors are subordinate to those of the project's debt financiers (Estache and Strong, 2000). Therefore, equity providers take on the greatest risk of loss if the project experiences difficulties. This risk is balanced by a higher return if the project performs better than expected. The major equity investors are the members of the ProjectCo, while several other parties can contribute.

Debt finance is senior to equity and is often secured against the assets of the project; hence the return expected by debt financiers is lower than that of equity providers. Debt financiers have no stake control in the ProjectCo, but enjoy great leverage on issues of project execution. A mixture of short- and long-term loans are usually utilised in a project. Short-term loans are used to finance the construction phase. Several types of financial institutions are capable of providing short-term finance. Long-term debt is generally provided by a syndicate of commercial banks during the operational phase of a project (Nevitt and Fabozzi, 1995).

3.4 BSF Development Stages

This section will outline BSF development stages. This is necessary as the understanding of the BSF process and how projects are structured is important for considering the implications for SEI. Figure 3.3 (see p. 80) illustrates the main BSF development stages.

3.4.1 Stage 1: Procurement Preparation

i. Project Initiation and the Strategy for Change (SfC)

The first stage of BSF development was project initiation, which defines the BSF project and was the basis for the management and assessment of project success. The result of this stage was the Project Initiation Document (PID). The PID enabled the Local Authority to demonstrate that the project has a sound basis before fully committing to the project.

The 'Strategy for Change' (SfC) was the first key document that the Local Authority needed to produce and agree locally. In expectance of BSF funding, local authorities developed their own plans for secondary education in consultation with local schools and key stakeholders. School staff, governors and the local community were required to engage in developing the 'Strategy for Change'. It was also necessary for local authorities to consider their current position for educational outcomes and evaluate the added value the BSF investment was to provide to local educational outcomes. The options appraisals for each school site needed to be based on a thorough examination of what was possible at different levels of spending, before identifying a preferred option. The starting point for developing the options was the schools' vision. The preferred option for each school was to balance educational aims with deliverability, taking into consideration costs and site constraints. The strategy also confirmed the affordability of the estate proposals and the ability to meet the running costs of the buildings and services.

iii. The Outline Business Case (OBC)

The OBC offered a detailed assessment of the achievability and affordability of BSF. It provided sufficient detail to obtain formal approval to begin the procurement of a Private Sector Partner. Specifically, the OBC included (PfS, 2008):

- Detailed feasibility studies for all of the schools in the wave showing block-by-block plans for changes to each school site.
- A VfM appraisal, using a Treasury method to consider the whole wave, and specifically proposals to use PFI.

- An evaluation of affordability which outlined how each element (PFI, D&B schools, ICT, facilities management, and maintenance) can be afforded from established resources. Local authorities needed to demonstrate their confidence in the affordability of the scheme through the Cabinet agreeing the commitment of Local Authority funds to the scheme, including the meeting of any affordability gap. It was also required from school governing bodies to commit future revenue-funding to finance agreed levels of service for ICT, facilities management, maintenance, and other services provided through a PFI agreement.

- Confirmation of Readiness to Deliver. This demonstrated that local authorities' project management resources were sufficient to begin the procurement phase and that adequate funding is allocated. It also included confirmation of the commitment of the Local Authority, schools and other delivery partners to the plans.

3.4.2 Stage 2: Procurement

The BSF procurement process was lengthy and expensive (NAO, 2009). Originally in 2004 PfS estimated that procurement would take between 60 to 78 weeks, measured from publishing an Official Journal of the European Union (OJEU) notice to signing of contracts. In reality, local authorities have on average taken 102 weeks to procure their Private Sector Partners (NAO, 2009). The NAO (2009) also identified that the total cost of establishing the first 15 BSF LEPs, in terms of the Local Authority's and the winning bidder's staff time, consultants, and legal costs, averaged between £9 million and £10 million. The key stages of this procurement process are explained below:

i. OJEU Notice and Prequalification Questionnaires (PQQs)

The first stage of procurement began when an OJEU notice was posted, advertising the project to potential bidders, a requirement for all European contract tenders above a certain value. Bidders expressing an interest in the project were then issued with a Prequalification Questionnaire (PQQ) which obtained information about the potential bidders' technical capacity, economic and financial standing to deliver the project. The PQQs were evaluated and a long-list of bidders was produced and invited to take part in the next stage.

ii. The Invitation to Participate in Dialogue (ITPD)

The dialogue phase began once the Invitation to Participate in Dialogue (ITPD) was sent to the long-listed bidders. The ITPD documentation included the Output Specification, proposed contractual terms, the Payment Mechanism, risk allocation arrangements, and bid evaluation criteria, which included mandatory items such as VfM and design compliance, as well as desirable criteria such as innovation and sustainability (PfS, 2006). The purpose of the dialogue phase was to 'identify and define the means best suited for satisfying the Local Authority's needs' (PfS, 2006, p. 8). The dialogue was conducted in 'successive stages' allowing the number of solutions to be reduced as the process continued. The first stage of dialogue allowed the Local Authority to reduce the number of bidders by applying the stated award criteria in the OJEU notice and tender documents and producing a shortlist of bidders with whom to progress to the next stage of the dialogue (PfS, 2006).

iii. The Invitation to Continue Dialogue (ITCD)

The second stage in the dialogue phase took the form of informal discussions with bidders on all aspects of the contract as well as more formal procedures. The Local Authority needed to guarantee *equal treatment* throughout the process and that no information was provided in a discriminatory manner which might offer some bidders an advantage over others (PfS, 2006). In addition, *confidentiality* was important and one bidder's solutions or other confidential information was not to be revealed to other bidders without their permission (PfS, 2006). It was necessary that the dialogue continued until the Local Authority was confident that it clearly identified and specified its detailed requirements, the solutions capable of meeting them, and thus the basis on which final tenders were to be submitted (PfS, 2006).

iv. The Invitation to Submit Final Bid (ITSFB)

After declaring the end of the dialogue phase and informing bidders, the Local Authority invited the remaining bidders to submit their final tenders based on identified solutions during the dialogue phase. Final tenders needed to include all the elements required for undertaking the project (PfS, 2006). However, not all issues needed to be fully agreed as part of the final tender submission. For example, the BSF requirement was for the design to be developed to RIBA Stage D for the Preferred

Bidder to be selected. This is then progressed with the Preferred Bidder to RIBA Stage F. In addition, detailed planning applications were not usually submitted until Preferred Bidder stage. Final tenders needed to be assessed based on the award criteria stated in the OJEU notice and tender documents in order to select the Preferred Bidder who submitted the 'most economically advantageous Final Tender' (PfS, 2006, p. 8).

v. The Final Business Case (FBC)

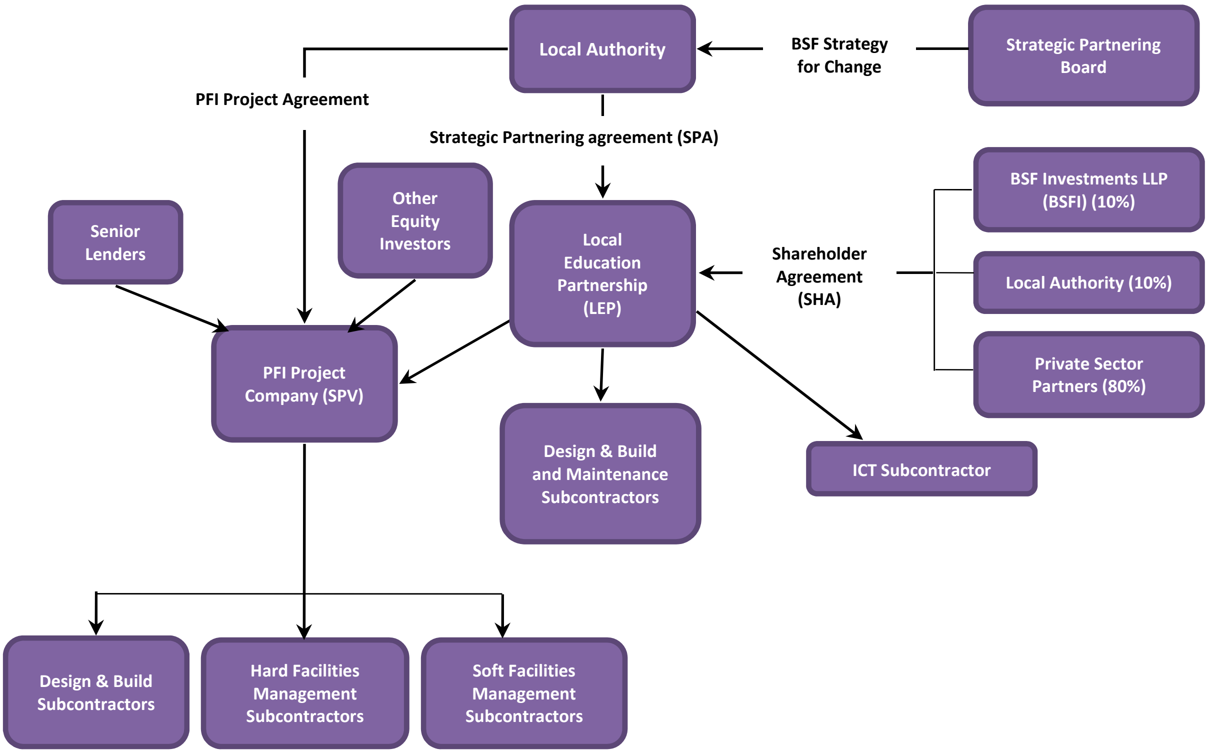
Having nominated a Preferred Bidder, the Local Authority began negotiations with the Preferred Bidder on the final solutions and details of the contract. The nature of the project-facility, the operational service provision, and related Unitary Payment were negotiated and agreed. Once the Local Authority and the Preferred Bidder agreed the terms of the contract to a state where it only needed to be signed, the Local Authority needed to have the project approved. The Local Authority produced a Final Business Case (FBC) to justify the award of the contract. The FBC confirmed the positions achieved from the OJEU stage through to Financial Close, and described the impacts and benefits of changed positions. It provided a description of the agreements being signed and outlined in detail, how development processes were to be delivered, including the structuring of resources for both the Local Education Partnership (LEP) and the Local Authority. The FBC constituted the basis for approval of funding for the project and permission to sign the contract. It needed to be approved by PfS and DCSF. Once approval has been granted, the Local Authority and PfS commit to signing the contract and to forming the LEP.

vi. Contract and Financial Close

a. Forming the LEP

To form the LEP, two key agreements needed to be reached: BSF Shareholder Agreement (SHA) and Strategic Partnering Agreement (SPA). The SHA is an agreement between the parties forming the LEP. The shareholders entering the SHA are the Local Authority (10%), BSFI (10%) and the Private Sector Partner (80%). The LEP would then enter into an SPA agreement with the Local Authority. The SPA runs from the date of the agreement for ten years and can be extended up to a further five years. The exclusivity granted to the LEP relates to the provision of the school facilities as well as the specified partnering and project services to the approved projects. The LEP can also provide ICT, maintenance, and other building-related services to some or all of the specified schools in the long-term. The LEP performed as the single point of contact for procuring, delivering, and integrating all the services required. Figure 3.2 explains BSF main contractual relationships (also displaying the PFI SPV contractual relationships).

Figure 3.2: BSF Main Contractual Relationships



Source: PfS (2004)

b. The BSF PFI Project Agreement

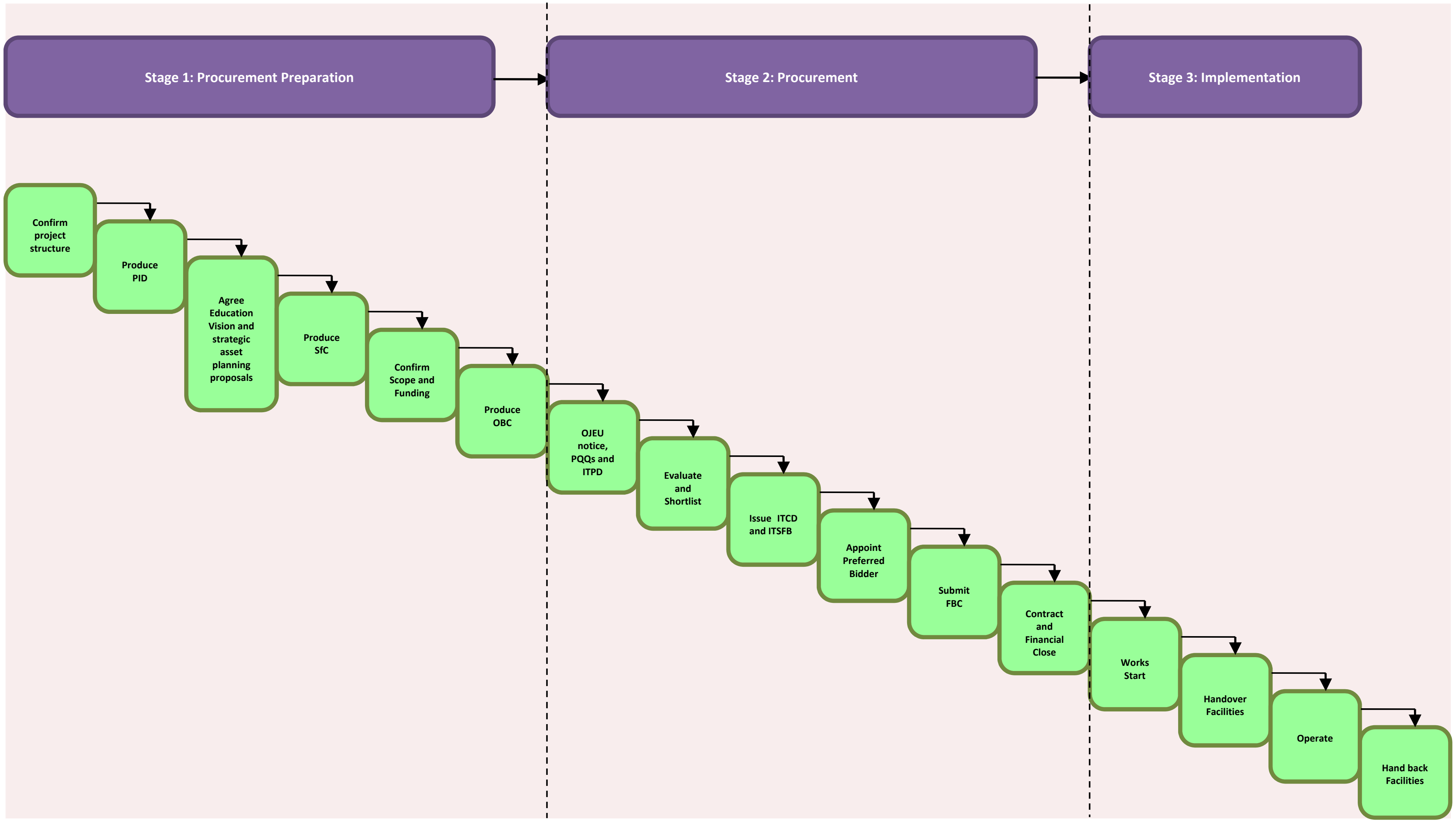
Alongside setting up the LEP, a PFI contract was signed for the delivery of the new-build element of the BSF programme. The parties in a BSF PFI Project Agreement were the Local Authority and the entity providing the services under the PFI Agreement, and that is the PFI ProjectCo (SPV). Under the Agreement the SPV is responsible for designing, building, financing, operating, and maintaining the relevant schools for the duration of the contract, normally between 25 and 30 years. At inception, under the BSF contractual documents, the LEP would have a controlling stake in the PFI SPV in terms of share capital and voting rights. The risks allocated to the PFI SPV are set out within the PFI project agreement and the use of the LEP procurement model was not intended to alter this arrangement. As investors into PFI SPVs, LEP sponsors assumed the same protections and risks as equity sponsors into existing PFI SPVs with the exception of the contractual terms within the Strategic Partnering Agreement (SPA) related to the performance of the PFI SPV and the impact of this on either exclusivity provisions or termination of the SPA.

3.4.3 Stage 3: Implementation

BSF PFI projects progressed into their implementation stage at Financial Close. The SPV's responsibility was to ensure that each school included in the Agreement is built and ready for use by a stated date. The SPV will receive no payments until this time, other than for Interim Services and in certain circumstances, often when the Local Authority suggests a change to its requirements, where there are changes in Law or when the Local Authority breaches its obligations. If the SPV fails to meet this deadline, then in limited circumstances the Local Authority may seek liquidated damages. When the SPV deems the school complete, the school will be independently certified. The independent certifier will examine the school and issue an Acceptance Certificate if the school successfully meets all the requirements set out in the Agreement. This will mark the beginning of operations and payment of the Unitary Charge for the services to be provided during the Service Period.

The SPV is also responsible for maintaining the school throughout the period of the Agreement. This often involves both 'Hard' maintenance (e.g. replacement of boilers or other fixtures and fittings) and 'Soft' facilities management services (e.g. catering and cleaning). The Agreement is 'output-based' and specifies a minimum level of service to be provided throughout the Service Period. If the services are not delivered to the required standard then full payment of the Unitary Charge will not be made and deductions will be issued. To the extent that the performance of the SPV is sufficiently poor then this can lead to termination of the contract. At the end of the contract the school is returned to the Local Authority in the same condition as it was first built.

Figure 3.3: BSF Development Process



Source: 4Ps (2005)

3.5 Key Characteristics of BSF PFI Project Delivery Model

The previous section provided a thorough description of BSF development stages. The aim of this section is to reiterate and highlight key characteristics of BSF PFI project delivery model that differentiate this procurement strategy from more traditional approaches, thus creating the distinct BSF PFI environment in which private sector actors operate and innovate. In addition, these characteristics may shape the interactions between the public sector Client/User and the private sector Producer, and within the Producer's supply chain. In the case of BSF PFI projects, the public *Client* is represented by the Local Authority, the principal client for all building, ICT, and facilities contracts while the public *User* is the School, the ultimate user of the new facility. The private *Producer*, on the other hand, is ultimately the ProjectCo; the group of private sector actors who come together to bid for and, later, to implement the PFI project. Attention will first be focused on the nature of the BSF PFI Output Specification. Second, BSF PFI engagement processes will be explained. Third, three characteristics of the BSF PFI contract will be highlighted, specifically ProjectCo integration under the DBFO contract, BSF PFI risk allocation, and the BSF PFI Payment Mechanism.

3.5.1 The BSF PFI Output Specification

The range of services in a PFI project is defined in the Output Specification outlining the needs of the public sector client and the responsibility of the Private Sector Partner (Cole, 2007; Robinson and Scott, 2008). Service specifications are often either input- or output-based. Input specifications, sometimes termed 'prescriptive' specifications, are defined by Heavisides and Price (2001) as 'documents that traditionally detailed the exact requirements of the service, the likely hours required to provide that service and the exact inputs needed to replicate or improve the existing service provision' (p. 344). This form of specification is being challenged by Output Specification, also termed 'performance-based' specification (Heavisides and Price, 2001). Contrary to input specification, which focuses on 'how' a facility should be delivered by specifying the exact dimensions, materials, and workmanship, an Output Specification concentrates on 'what' is required in terms of accommodation standards and services (Robinson and Scott, 2008). Government guidance advocates that output-based specification provides more scope for innovation and flexibility in service delivery than traditional input-based specification (HM Treasury, 1999). As

McDowall (1999) notes, output-based specification has altered the way buildings and services are specified by concentrating on those elements of performance crucial to clients and the way the completed facilities will perform. Table 3.2 provide an example of energy-related input- vs. output-based specification.

Table 3.2: Example Input- vs. Output-based Specification

Input-based Specification	Output-based Specification
Replacement of oil-fired boiler providing a heating capacity of X.	Heating system designed to heat Room X to a temperature of X for X hours per day, and Room Y to a temperature of Y for Y hours per day, with a primary energy consumption of Z.
Supply and installation of XXX light bulbs of XXX Watts, and XXX light fixtures.	Classrooms need to be lit to XX quality for XX hours per day. Corridors need to be lit to YY quality for YY hours per day. *Environmental performance characteristics can also be formulated as follows:* Electricity consumption of the lighting system installed must be XX% lower than the current system.

Source: Clement *et al.* (2009)

The Output Specification is one of the key procurement mechanisms in PFI (Rintala, 2004). The Local Authority, in collaboration with schools, set out their objectives and requirements (which are the provision of a school building with specified facilities and operating it to required standards) in a document known as the Output Specification. The Output Specification should provide detailed description of the functions the new accommodation should be able to perform, usually divided into building functions and service functions. The Output Specification on PFI projects also needs to indicate how the different aspects of bidders' proposals will be rewarded in bid evaluation. The Local Authority then invites potential ProjectCos to develop their proposals based on those requirements. The need for BSF to meet national standards and deliver government policy meant that service specification within the programme was largely directed by guidance and required an element of control (DfES, 2005a). PfS has developed standard Output Specification for PFI and D&B projects to provide an established starting point across the programme. As DfES (2005a) advises, variations are inevitable, but PfS and its coordination project directors work with local authorities to ensure consistency. Success of the project is measured against the Output Specification for delivered outcomes and outputs (DfES, 2005a).

3.5.2 BSF PFI Engagement Processes

Stakeholder engagement was a central commitment demanded by PfS (PfS, 2006, 2008). The BSF engagement process was specifically designed to allow the Local Authority and potential ProjectCos to discuss solutions, develop ideas, and explore options during the tender process. The aim of the dialogue was to 'identify and define the means best suited for satisfying the Local Authority's needs' (PfS, 2006, p. 8). It allowed the Local Authority and ProjectCos to discuss all aspects of the project and can, for example, take the form of formal presentations, written bid-type phases, development of design, formal clarification, and negotiations of solutions and contract terms.

School involvement in the design development process was also required by PfS (PfS, 2006, 2008). PFI guidance stresses the importance of direct communication between the designer and the ultimate end user (HM Treasury, 2000a). BSF engagement processes are designed to provide the opportunity for sample schools to engage with potential ProjectCos and provide detailed feedback on their developed design proposals. Schools, with the help of their advisors, evaluated the designs against their ambitions as set out at briefing stage. By assessing designs midway through the dialogue phase, the ProjectCos were given the opportunity to respond to any improvements and suggestions presented by schools during the remainder of the dialogue stage. By doing so, BSF may avoid the criticism endured by early PFI deals, in which contractors had limited involvement with end users[2].

3.5.3 The BSF PFI Contract

Contracts, as governance mechanisms, are intended to achieve two main goals: to outline the structure of authority-responsibility, and share risk and reward among project partners (Giannoccaro and Pontrandolfo, 2004; Sen and Mitra, 2000). Three characteristics of BSF PFI contracts particularly distinguish this project delivery model from traditional procurement: (i) ProjectCo integration under DBFO contract; (ii) BSF PFI risk allocation, and (iii) BSF PFI Payment Mechanism.

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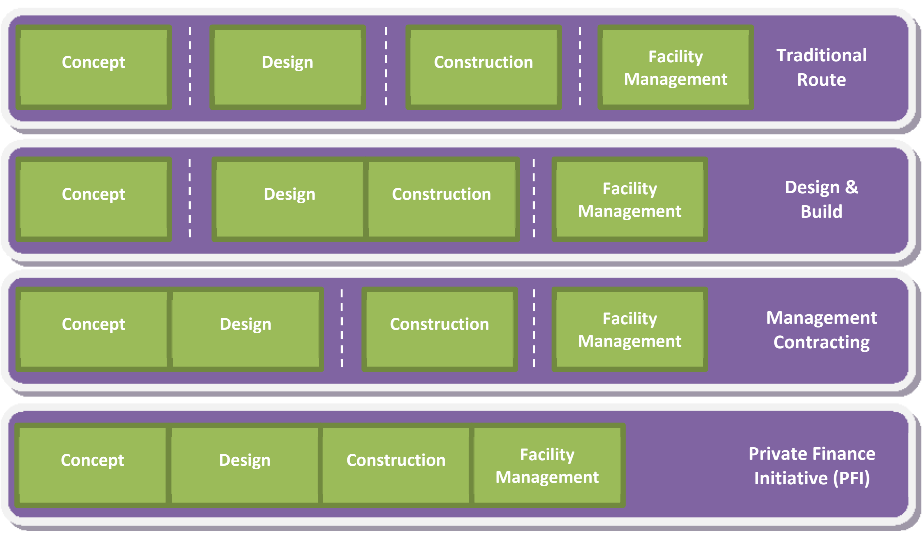
[2] An example of a lack of schools' involvement in early PFI projects could be found in the Edward and Shaoul's (2003) case study on the redevelopment of Pimlico School, Westminster City Council.

i. ProjectCo Integration under DBFO Contract

The contracting authority awards a PFI project with a single Design Build Finance and Operate (DBFO) contract. The contract allows the ownership of the facility to be transferred to the ProjectCo for the duration of the concession period. In order to bid for the project, the ProjectCo brings together a large number of actors with a wide range of skills to develop the bid and subsequently undertake the project. This is because it is unlikely that any one actor would have all the necessary skills required (CIC, 1998). This allows the opportunity for ProjectCo actors to simultaneously consider all the tasks involved in the DBFO contract at the beginning of project development (CIC, 2000).

The Local Authority's use of the PFI delivery model, and thus task integration, is said to remedy many of the organisational and contractual barriers brought about by the fragmented and sequential traditional procurement methods (Rintala, 2004). Several procurement methods exist in the construction industry, including traditional lump sum (fixed price), Design & Build (D&B), Management Contracting, and the Private Finance Initiative (PFI). What distinguish the different modes of procurement are the integration of the different project life cycle stages and the ownership of these stages (Horsley, 2003a). Figure 3.4 illustrates the fragmentation of traditional procurement.

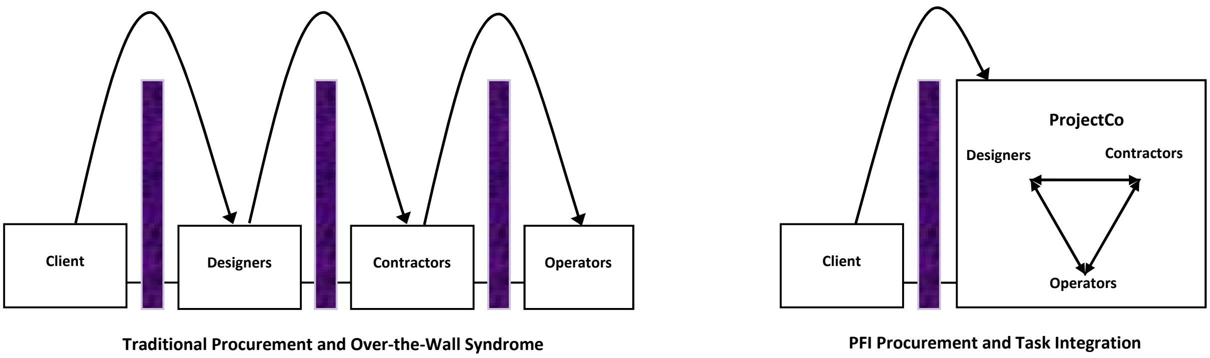
Figure 3.4: Four Major Building Procurement Routes



Source: Horsley (2003a)

The traditional procurement route often draws the most criticism in the literature and is considered the most detrimental to innovation (Walker and Hampson, 2003ab). Ultimately traditional systems of procurement involve the 'highest cost risk for contractors, the highest incidence of adversarial relationships, the lowest level of integration across the supply chain, and the poorest innovation outcomes' (Kumaraswamy and Dulaimi, 2001, in Blayse and Manley, 2004, p. 149). PFI, however, allows the introduction of some private sector actors at the inception of PFI project development, while those actors would have been introduced at much later stages in traditional project development (Rintala, 2004). Figure 3.5 shows why the Over-the-Wall Syndrome in traditional procurement ceases to prevent innovation in PFI projects.

Figure 3.5: Traditional vs. PFI Procurement and Task Integration



Source: Rintala (2004)

Indeed, previous research on PPP/PFI highlighted the growing belief that the integrated procurement context under PFI may provide a more supportive environment for collaborative relationships, with the ProjectCo performing the role of the 'System Integrator' (Barlow and Köberle-Gaiser, 2008b). The ProjectCo, as a vital coordinator, assuming design, construction and operational responsibility for the fixed capital asset, is often seen to provide system integration and coordination capabilities (Davies and Salter, 2006). ProjectCo integration is seen to accelerate the design process, and stimulate innovation through improved communication and collaboration (Davies and Salter, 2006; Barlow and Köberle-Gaiser, 2008b). Indeed, PFI is widely seen as an improvement to the traditional procurement practices that prevailed in the construction industry prior to its inception (Robinson and Scott, 2008; Carrillo *et al.*, 2006). In traditional procurement systems, the separation of design, construction, and operation has created conflict between stakeholders and resulted in buildings that deliver poor services (Robinson and Scott, 2008). This separation has led to what Winch (2000b) referred to as 'Build And Disappear' (BAD) practices. In PFI contracts, on the other hand, the ProjectCo has to 'Build, Evaluate, and Stay Throughout' (BEST) the concession period of 20 to 30 years. Thus, PFI represents a move from BAD to BEST practices in terms of design, construction, and operation integration (Robinson and Scott, 2008).

ii. BSF PFI Risk Allocation

The literature identifies several categories of risks in PFI projects (HM Treasury, 1997b; Jackson, 2004; Grimsey and Lewis, 2002; Rintala, 2004) as outlined in table 3.3.

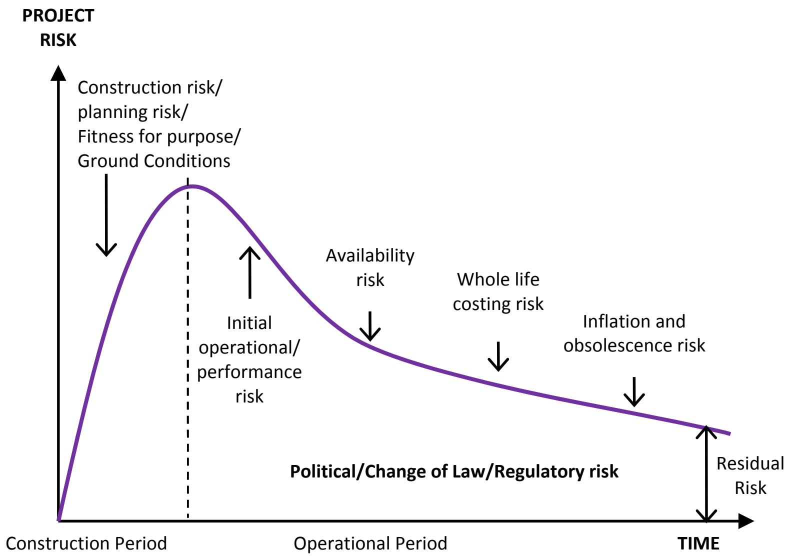
Table 3.3: Risk Types in PFI Projects

Risk	Description
Availability Risk	The risk that the quantum of the service provided is less than required under the contract.
Design Risk	The risk that the design will be unable to meet the performance and service requirements in the Output Specification. This includes issues such as buildability, fitness for purpose, and functionality of the proposed technical solutions.
Technology Risk	The risk that changes in technology result in services being provided using non-optimal technology.
Construction Risk	The risk arising from the uncertainty that the project will be delivered to agreed specification, schedule, and budget.
Operational Risk	The risk that operating costs vary from budget, that the performance standards slip, or the service cannot be provided.
Energy Risk	Energy risk is divided into *Energy Consumption Risk* and *Energy Price Risk*. • Energy Consumption Risk: the risk that the building's operational energy consumption is beyond agreed standard for maximum annual energy consumption in the contract. • Energy Price Risk: the risk of fluctuations in the market price of energy.
Maintenance Risk	The risk that the cost of keeping the asset in good condition varies from budget.
Planning Risk	The risk that the implementation of a project fails to achieve the terms of planning permission, or that detailed planning permission cannot be obtained, or, if obtained, can only be implemented at costs greater than in the original budget.
Regulatory/Political Risk	The risk arising from legal changes and changes in government.
Environmental Risk	The risk that the project will have adverse environmental impacts beyond permitted limits. This may be the result of environmental changes and regulations.
Financial Risk	The risk arising from inadequate hedging of revenue streams and financing costs. Included in this category are issues such as refinancing of the project, the stability of the local currency, and taxation issues.
Revenue Risk	The risk that revenue gained from the project over the project term varies from initial expectations. It includes ownership risks such as the construction of a competing facility or premature obsolescence.
Project Default Risk	The risk that the Private Sector Partner or its subcontractors are unable to fulfil their contractual obligations through a combination of any of the other risk categories.

Source: HM Treasury (1997), Jackson (2004), Grimsey and Lewis (2002) and Rintala (2004)

Treharne (2003) also offers an illustrative presentation of the timing of each risk in Figure 3.6 below. He argues that risk is highest in the early stages—construction and commissioning—with a gradual decrease during the operation stage (Treharne, 2003).

Figure 3.6: Typical Risk Profile in PFI



Source: Treharne (2003)

A major characteristic of PPP/PFI projects is the transfer of risk from the public sector to the private sector. Traditionally, construction projects entail the purchase of a product, largely governed by legal contracts, and based on fixed specifications and profit levels. The client assumes most of the risks, though risks related to the project end dates and construction methods are passed down the supply chain (Barlow and Köberle-Gaiser, 2008b). A major consideration for the government in introducing PFI was the transfer of risk from the public sector to the private sector in order to introduce more discipline in risk analysis and allocation into public sector procurement (PWC, 2008). Therefore, appropriate risk transfer is a fundamental requirement for VfM to be achieved in PFI procurement. While the contractual liability for a contractor under a traditional procurement contract is limited to a shorter period, usually 12 months, under PFI the contractor is often liable for the delivery of the assets and a wide range of other services for the duration of the Service Period spanning 25–35 years (Gruneberg *et al.*, 2007; Robinson and Scott, 2008).

Among the major risks allocated to the ProjectCo under BSF PFI projects are: design and construction risk, availability risk, detailed planning risk, and energy consumption risk. In PFI projects, the client often allocates the design and construction risks to the ProjectCo as it is best positioned to manage them and is thus willing to assume their responsibility without a high premium (NAO, 1999a). However, Rintala (2004) notes that due to this increased risk transfer, the price of the design and build (D&B) element of a PFI project is more likely to be higher than the market price for procuring design and construction independently. The reason for this is the premium included in the ProjectCo's prices for design and construction risk management (Rintala, 2004). In addition, NAO (1999a) advise that the client should transfer the availability and maintenance risks to the ProjectCo as it is best placed to manage them (NAO, 1999a). Rintala (2004) also adds that clients can achieve an effective transfer of availability and maintenance risks by linking the Unitary Payment to the availability of the project-facility. Moreover, TTF (1999d) stresses the need for the ProjectCo to take on the risk of obtaining detailed planning permission as it is responsible for developing the documentation needed to gain the permission and thus is best placed to manage the risk.

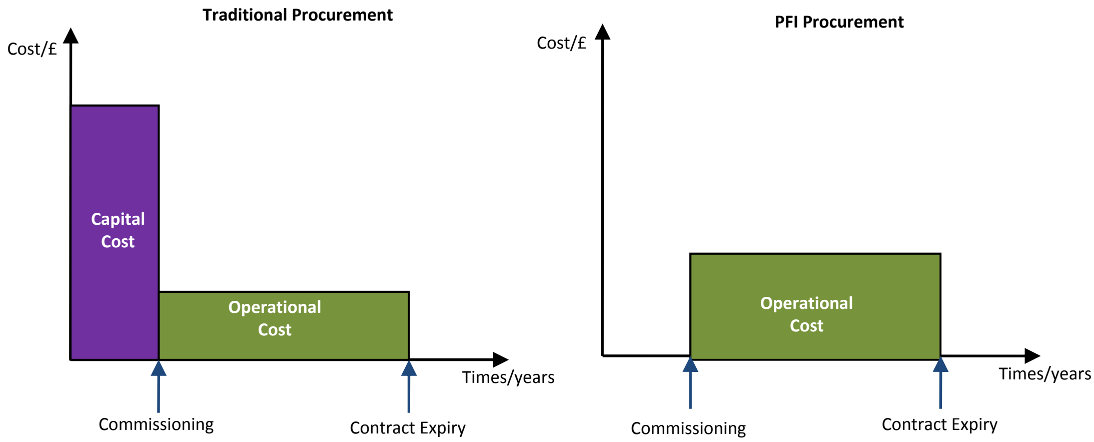
Energy risk is divided into energy consumption risk and energy price risk. The BSF PFI contract transfers the risk of energy consumption onto the ProjectCo SPV and FM Provider. The reason for this was to encourage the energy-efficient management and operation of school buildings (Sustainable Development Commission, 2006). Energy price risk is assumed by the ProjectCo SPV and FM Provider for the first three years. Subsequently, following a benchmarking exercise, it is retained by the Local Authority. This was decided so as not to expose the ProjectCo SPV and FM Provider to the risk of price volatility, and to benefit from the Local Authority's ability to negotiate better energy tariff (Sustainable Development Commission, 2006).

iii. BSF PFI Payment Mechanism

The PFI Payment Mechanism is the centre of the contract as it transforms into financial effect how risk and responsibility are allocated between the ProjectCo and the Local Authority (DfES, 2005a). The Payment Mechanism is seen as the main method by which the contract encourages the ProjectCo to maintain the quality of services at all stages of the contract, and ensures timely delivery (DfES, 2005a). The ProjectCo is paid through a Unitary Charge that will be triggered by service commencement sign-off as stated in the contract. Therefore, any delay in service commencement will be of concern to the ProjectCo, given the financial pressures it produces (DfES, 2005a). The

ProjectCo financing will often be structured with limited contingency to deal with delays, particularly where senior debt is concerned (DfES, 2005a). The ProjectCo risks cash-flow shortage as senior debt obligations are not met by unitary charge payments from the Local Authority, resulting in revenue loss as well as reduction in revenue periods (DfES, 2005a). No payment is made to the ProjectCo until the school is designed, built, commissioned, and ready for use. This is distinctly different from a traditional building contract for which the client pays progressively as construction proceeds. Rintala (2004) shows the difference in the timing of payments in PFI and in traditional procurement in Figure 3.7.

Figure 3.7: Comparison of Payment in Traditional and PFI Procurement



Source: Rintala (2004) from PFPE (1996)

The economic Principal-Agent theory has been placed in the PPP/PFI context by Mumford (1998). In a PPP project, the Principal is the client that purchases a facility-based service. The Agent is the ProjectCo that provides the client with the serviced facility. The DBFO contract between the client and ProjectCo allocates some of the responsibilities, risks, and rewards that the client typically retains in traditional procurement to the ProjectCo. As a consequence of that, the client provides the ProjectCo with the incentive to deliver the serviced facility to the client's pre-defined standards throughout the development and operational stages of the project. Indeed, the PFI Payment Mechanism is seen as the main method by which the client encourages the ProjectCo to maintain the quality of services at all stages of the contract, and ensures timely delivery (DfES, 2005a).

With a PFI contract, the Local Authority will be paying for services, (e.g. availability of classrooms for teaching in a clean, safe, and warm environment). Failure of the ProjectCo to make the accommodation available to these standards as stated in the contract activates the use of payment deductions. This may take the form of unavailability deductions, area failure deductions, ratchet and service performance deduction provisions in the contract, which all affect the Unitary Charge payments (DfES, 2005). Consequently, the amount of revenue the ProjectCo will receive from the project will be reduced. The prospect of deductions provides the ProjectCo with an incentive not to reduce the service. A failure to meet the level of service specified in the Output Specification can result in the termination of the contract, in what is known as a 'forcing contract'. The forcing contract gives the client the assurance that the service provided by the ProjectCo will meet the Output Specification throughout the operational phase (Douma and Schreuder, 1998).

3.6 Summary

This Chapter provided the background for the BSF PFI delivery model. The Chapter started by introducing PFI as a form of Public Private Partnership (PPP) and PPPs were defined and the motivation for their adoption explained. The next step was to examine the delivery model of BSF projects highlighting the key actors and development stages. Finally, key characteristics of the PFI project delivery model that distinguish it from traditional procurement are presented. These characteristics are particularly important as they create the distinct BSF PFI environment in which private sector actors operate and innovate. Attention was first focused on the nature of the BSF PFI Output Specification. Second, BSF PFI engagement processes were explained. Third, three characteristics of the BSF PFI contract were highlighted, specifically ProjectCo integration under the DBFO contract, BSF PFI risk allocation, and the BSF PFI Payment Mechanism. These characteristics are of particular importance to innovation and should be considered as part of the explanation of the phenomenon.

Having identified the key characteristics of the PFI project delivery model, the next Chapter will attempt to further develop the issue by building a conceptual framework to examine the capacity of the PFI project delivery model to support the implementation of SEI on BSF new-build school projects.

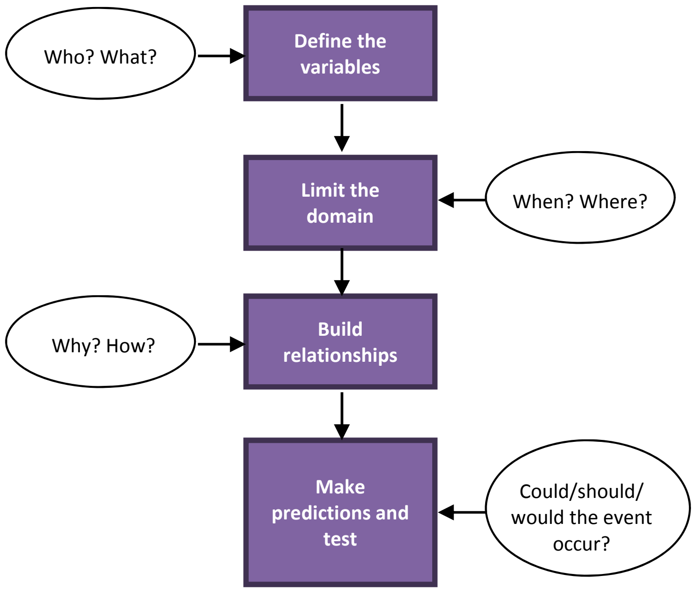
Chapter 4: Developing the Conceptual Framework

4.1 Introduction

The objective of this Chapter is to translate the study's first research question – ***What is the capacity of the PFI project delivery model to support the implementation of Sustainable Energy Innovation (SEI) on BSF new-build school buildings?*** – into a conceptual framework and research propositions. It is necessary to commence the discussion on this Chapter by explaining the logic underlying the conceptual framework. A central line of reasoning for this research study is that innovation for sustainable energy needs to be understood as a multidisciplinary activity spanning several organisations and circumstances (Rohracher, 2003, 2005; Ornetzeder and Rohracher, 2006; Heiskanen and Lovio, 2007). As was explained in Chapter 2, and following previous studies such as those of Barlow and Köberle-Gaiser (2008ab) and Caldwell *et al.* (2009), the BSF PFI project is conceptualised as a Complex Product Systems (CoPS) supply network (Hobday, 1998) where success in innovation is largely determined by the interactive relationships among multiple project partners (Hobday, 1998, 2000; Hobday *et al.*, 2000; Gann and Salter, 2000). In order to examine the relationship between the PFI project delivery model and SEI, it is, therefore, necessary to consider the interactions between the different organisations involved on BSF PFI project developments. Particularly, the study adopts the view that innovation activities need to be understood in terms of an interactive relationship between the public sector clients/users and private sector producers, and within the producers' supply chain. In BSF PFI projects, the public *Client* is represented by the Local Authority, the principal client for all building, ICT, and facilities contracts while the public *User* is the School, the ultimate user of the new facility. The private *Producer*, on the other hand, is ultimately the ProjectCo; the group of private sector actors who come together to bid for and, later, to implement the PFI project. Adopting such a system-oriented approach is particularly important for SEI as the functional dependency and components complexity of such innovations necessitate effective interaction among producers, clients, and users for their successful development (Rohracher, 2001; Intrachooto and Horayangkura, 2007).

To develop the conceptual framework, a procedure for theory building is adopted that involves defining the variables, specifying the domain, building internally consistent relationships, and making predictions (Hunter and Kelly, 2008). Figure 4.1 highlights the process that should be undertaken (Wacker, 1998).

Figure 4.1: Building the Conceptual Framework



Source: Wacker (1998) in Hunter and Kelly (2008)

The first steps in developing the conceptual framework involve defining the variables and limiting the domain of the investigation. On this research study, the following three determinants of CoPS innovation, identified in Chapter 2, are considered to be of particular importance to understanding SEI on BSF PFI projects and should be considered as part of the explanation of the phenomenon:

1. Clarity of the requirement (Hansen and Rush, 1998; Hobday and Rush, 1999; Ren and Yeo, 2006).
2. Communication and collaboration:
    i. Producers' multidisciplinary communication and collaboration (Miller *et al.*, 1995; Hobday, 2000; Brady *et al.*, 2005).
    ii. Client-Producer communication and collaboration (Gardiner and Rothwell, 1985; Miller *et al.*, 1995; Hobday, 1998).

    iii. User-Producer communication and collaboration (Hobday, 1998; von Hippel, 1988, 1998; Lundvall, 1988).
3. Contractual incentives:
    i. Risk allocation (Hobday, 1998; Miller and Lessard, 2000).
    ii. Reward sharing mechanisms (Hobday, 1998; Millerand Lessard, 2000).

The next steps in developing the conceptual framework involve building relationships and making predictions. Each determinant of CoPS innovation is explored in more detail in this conceptual Chapter and six research propositions are developed. Indeed, in this research study, the adopted theory is presented through propositions (Yin, 1994). Each proposition is developed from related parts of the theory and focuses attention to an issue that is to be examined in the investigation. A proposition is defined by Leiringer (2003) as 'a theoretical statement that provides an explanation of the phenomena of interest' (p. 116). A study's propositions serve as the bases upon which relevant empirical data can be collected since they form a guide to the collection of information (Leiringer, 2003). The study proposes six causal relationships based on innovation determinants postulated in CoPS theory, and supported by related studies of New Product Development and construction innovation. Together these conceptual perspectives will serve as a valuable foundation upon which to develop an understanding of the capacity of the PFI project delivery model to support the implementation of SEI on BSF new-build school projects.

4.2 The Propositions

4.2.1 Proposition 1: Clarity of the Requirement

The clarity of the client requirement is seen as a key determinant of CoPS innovation as designs are tailored to fit their specific needs (Hansen and Rush, 1998; Hobday and Rush, 1999; Ren and Yeo, 2006). Indeed, system-oriented approaches to innovation identify the client's requirement as an important driver of innovation success (Pavitt, 1984). This is particularly important in the case of sustainable and environmentally-friendly innovations where client demand for higher environmental standards and specifications can force producers to improve their environmental performance (Kemp and Foxon, 2007; Seaden and Manseau, 2001; Gann and Salter, 2000; Barlow, 2000).

In the construction industry, Bossink (2004) studied the factors driving sustainability-related innovation. He identified that among the key drivers of innovation is challenging demands from governmental clients, securing markets for innovative firms and subsidising novel applications and materials. Oluwoye and Lenard (1999), Graedel (2002), and Beaudoin and Tremblay (2002) similarly underline the importance of sustainability targets for the development of green buildings. Anderson *et al.* (2004) and Richardson and Lynes (2007) equally recommend measurable sustainability targets as prerequisites for innovation. In fact, Blayse and Manley (2004) propose that policymakers can exert significant pressure on the construction industry to develop novel products and technologies by demanding standards far too difficult for existing technologies to meet, encouraging the pursuit of innovation.

The nature of the client requirement is also seen as an important determinant of innovation. It is often argued that outcome-based requirements, as opposed to input-based, are effective drivers for innovation (Johnson and Medcof, 2007; Heavisides and Price, 2001). Gann *et al.* (1998), Prior *et al.* (2004), and Sexton and Barrett (2004) also maintain that output-based building specifications are progressive and can work to encourage innovation. The key advantage of output-based specifications rests in their ability to allow choice and scope for decision preferences towards cost, quality, and process (Heavisides and Price, 2001). The Centre for Facilities Management (1999) also argues that output-based specification provides the 'innovation objective' and that is 'the ability of external service providers to innovate in service provision processes and make sustainable cost and quality improvements'(Heavisides and Price, 2001, p. 347). While traditional input methodologies are fairly prescriptive, complex and repetitive, output-based specifications are seen to release the innovation capacity of contractors, and, by doing so, many benefits are achieved (Heavisides and Price, 2001).

In CoPS projects, innovation success largely depends on the ability of the client to clearly articulate their requirements (Hansen and Rush, 1998). Indeed, particularly important to innovation is the greater clarity of the requirement in the Output Specification (4ps, 2005; Caldwell *et al.*, 2009; Kimmins, 2010). In addition to their Output Specification, public sector actors that procure capital assets rely on governing frameworks that include regulation, standards and norms to ensure that the facilities delivered conform to the criteria set for the specific context. Greater clarity of the requirement and governing framework is needed, as the main concern of an innovating organisation is the extent to which the innovation meets the criteria set for the particular setting, without increasing development costs, production or operation (Leiringer, 2003).

In summary, taking the above conceptual perspectives into consideration, we can, therefore, propose that the clarity of the sustainable energy requirement is an important determinant of SEI success. Indeed, the opportunity and incentive for project participants to innovate are seen to be directly linked to the nature of the client's requirements, specifications and constraints (Kamath and Liker, 1994; Tawiah, 2005). In the BSF PFI delivery model, the range of services required is defined in the Output Specification outlining the needs of the public sector client and the responsibility of the ProjectCo (Robinson and Scott, 2008). Contrary to input specification which focuses on 'how' a facility should be delivered by specifying the exact dimensions, materials and workmanship, an Output Specification concentrates on 'what' is required in terms of accommodation standards and services (Robinson and Scott, 2008). This is often seen to provide ProjectCo actors with greater flexibility to translate the client requirement (Leiringer, 2006) and, thus, releases their innovative capacity (Heavisides and Price, 2001). Particularly important is the greater clarity of the sustainable energy requirement and governing framework, as the innovative organisation's main concern is the extent to which the innovation meets the criteria set for the specific context, whilst the output-based nature of the requirement maintains the flexibility needed for innovation (Leiringer, 2003). Therefore, the following proposition is forwarded:

> **Proposition 1:** SEI is supported by the greater clarity of the sustainable energy requirement and governing framework on the BSF PFI Output Specification.

4.2.2 Proposition 2: Multidisciplinary Communication and Collaboration

The importance of effective multidisciplinary communication and collaboration for successful innovation was highlighted by many studies of CoPS (Miller *et al.*, 1995; Hobday, 2000; Brady *et al.*, 2005). In CoPS projects, changing user requirements and continuous feedback loops necessitates innovative non-functional organisational structures to coordinate production (Hobday *et al.*, 2000). Thus, systems integration and effective coordination capabilities have been seen as prerequisites for innovation (Geyer and Davies, 2000; Davies and Brady, 2000).

Similarly, effective communication and collaboration are seen as key drivers of innovation in New Product Development teams (Anacona and Caldwell, 1992; Reagans and Zuckerman, 2001; Burkink, 2002). Anacona and Caldwell (1992) suggest that New Product Development teams operate in an environment characterised by high complexity, high uncertainty, and multiple interdependency. Thus, communication, including cross-functional integration of specialised knowledge and negotiation of differences among domain specialists, is considered central to product development success (Sonnenwald, 1996; Clark and Fujimoto, 1992). In fact, interdependency among teams is a main concern in classic works in organization and management theory (e.g. Thompson, 1967; Galbraith, 1973; Mintzberg, 1983). Litwak and Hylton (1962) define *Dependence* as a condition where two entities must take each other into account if they are to fulfil their goals. Interdependency is seen as an important binding force to the organizations within a network (Lazzarini *et al.,* 2001). Indeed, Leenders *et al.* (2003) also emphasise that team creativity is highly influenced by the ability of its members to access an effective network of information and knowledge flows. The capacity of design development teams to gather information from and transmit information to several external and internal domains is one of the critical aspects of the innovative design process (Myers and Marquis, 1969; Miller, 1971; Kelly and Kranzberg, 1975).

In the construction industry, the importance of effective communication and collaboration for successful innovation was emphasised by many studies (e.g. Slaughter, 1993, 1998; Bresnen and Marshall, 2000a; Ben Mahmoud-Jouini, 2000). This largely stems from the multidisciplinary nature of the construction industry where project participants must combine their specialised knowledge from several disciplines to create innovative products and services (Sonnenwald, 1996; Dougherty, 1987). As a result, communication and collaboration among related parties is considered a necessity for project success (Pektaş and Pultar, 2006). Early work by Tatum (1984, 1989) maintains that ensuring effective information flow within the project team is an important innovation driver in construction projects. In his study of offshore construction projects, Barlow (2000) also emphasises that lateral communication facilitates the flow of knowledge among project participants and encourages creativity.

The need for effective communication and collaboration is particularly vital in the development of sustainable buildings (Rohracher, 2001; Anderson *et al.*, 2004; Intrachooto and Horayangkura, 2007). Intrachooto and Horayangkura (2007) emphasise the importance of close collaboration among designers, engineers and other consultants in order to introduce innovative environmentally-sound technologies into building systems. Rohracher (2001) also argues that different types of services and consultancy become important in the development of sustainable buildings as high levels of expertise are needed to deal with the multifaceted nature of environmental optimisation. Previous studies have particularly highlighted the importance of collaborative relationships among design, construction and operation disciplines (e.g. Dulaimi *et al.*, 2003; Ling, 2003; Errasti *et al.*, 2009; Song *et al.*, 2009). The integration of design and construction is often seen to facilitate cost saving and shortened project duration through increased constructability and affordability (Blayse and Manley, 2004; Rahman and Kumaraswamy, 2004; Errasti *et al.*, 2009; Song *et al.*, 2009), improved client satisfaction due to greater understanding of client requirements (Ahola *et al.*, 2008), improved environmental performance (Cole, 2000) and innovation (e.g. Ling, 2003; Caldwell *et al.*, 2009; Eriksson and Westerberg, 2010). Leiringer (2003) also believes that systematic involvement of those responsible for the building's operation as early as possible during the project life cycle can stimulate innovation. This is particularly important for environmental innovations, given the important role operators can play in the energy-efficient management of buildings (Haji-Sapar and Lee, 2005).

Overall, these conceptual contributions from CoPS, New Product Development, and construction innovation research emphasise the importance of effective communication and collaboration among project participants for successful innovation. In the BSF PFI delivery model, the Local Authority awarding a PFI project with a single Design Build Finance and Operate (DBFO) contract to integrated ProjectCos can thus work to encourage SEI. Open communication and effective collaboration among design, construction and operation disciplines may bring together the expertise needed to deal with the complexity of environmental design (Lutzenhiser, 1994; Rohracher, 2001; Anderson *et al.*, 2004; Intrachooto and Horayangkura, 2007) and stimulate innovation (Dulaimi *et al.*, 2003; Ling, 2003; Caldwell *et al.*, 2009; Eriksson and Westerberg, 2010). The following proposition is forwarded:

> **Proposition 2:** SEI is supported by open communication and effective collaboration within the integrated ProjectCo, particularly among design, construction, and operation disciplines.

4.2.3 Proposition 3: Client-Producer Communication and Collaboration

The importance of Client-Producer communication and collaboration was highlighted by several studies of CoPS (Miller *et al.*, 1995; Hobday, 1998). Early work by Gardiner and Rothwell (1985) underlined the role of the client in aircraft and agricultural machinery innovation and argued that the client should be a full 'partner' in the design process. As Gardiner and Rothwell (1985) argue ‘tough customers’ encourage superior designs. Nam and Tatum (1992a) studied the instruments used to stimulate innovation in construction projects. One of the key instruments they reported is client involvement. Nam and Tatum (1997) have shown that in such a context, clients may play the dominant role of ‘champions’ to innovative products and processes. Bröchner and Grandison (1992) and Mitropoulos and Tatum (1999, 2000) similarly argue that client’s involvement is a key driver for innovation. Robertson *et al.* (1996) and Hon and Fan (2004) identify the effectiveness of establishing partnering relationships between engineering contractors and their clients in stimulating innovation. Barrett and Stanley (1999) highlight the importance of the briefing process as central to client interaction. They also signal a tendency in the construction industry to view the brief as a ‘stand-alone’ document produced at the beginning of the project. Once in place, the brief is used by the project team to control any subsequent demands by the client as a way to manage costs and risk. Barrett and Stanley (1999) offer a fresh perspective by emphasising that the ‘briefing process should continue throughout the project and the client’s requirements should be progressively captured as they emerge’ (Barrett and Stanley, 1999 in Ivory, 2004, p. 497).

In addition, Cherns and Bryant (1984) point out to the construction client as being ‘a complex of interest groups, some congruent, some competing’. Multiple stakeholder groups may exist within the construction client, including procurement experts, funders and sponsors, all participating in defining, specifying, designing and managing the construction project (Ivory, 2004). Therefore, Barrett and Stanley (1999) emphasise the need for a single point of contact within the client organisation with the necessary level of authority to represent all internal stakeholders. This single point of contact may result in briefing information accurately reaching the design team (Barrett and Stanley, 1999). Moreover, research studies by Conway (1994, 1997), Stock (2006) and Hsu *et al.* (2007) have shown that a great proportion of this boundary-spanning interaction is undertaken by a small number of individuals in an organisation, known as *Boundary-spanners* (Allen, 1977; Friedman and Podolny, 1992; Levina and Vaast, 2004) or *Gatekeepers* (Tushman and Katz, 1980). Hartmann (2008) also argues that successful innovation requires key individuals who can span the boundary between the client organisation and the innovative construction project and who actively promote the adoption process to the client. He conceptualises the *Integration Champion* as a key individual who is able to successfully support the adoption process of construction clients. Bossink (2004) similarly stresses that empowering *Innovation Champions* is critical for environmental innovations in housing projects. According to Tatum (1989), Nam and Tatum (1992a), Barlow (2000), and Bossink (2004) the staffing for key positions, such as innovation champions and leaders, is important to the innovation process. Innovation champions act as drivers for innovation, while innovation leaders function as initiators and managers of the innovation processes in organisations and projects (Bossink, 2004). Richardson and Lynes (2007) examined the drivers and barriers to green buildings at a university campus. They concluded that one of the key drivers for success is client's internal leadership through a committed project champion with an open attitude to creative design. Indeed, Ivory (2004) emphasises the need to view the design as being promoted through networks, comprising not only designers (and other construction actors) but also multiple groups within the client. As Ivory (2004) maintains 'It is, therefore, most useful to conceive the design as being promoted through networks [...] rather than as being developed on the 'supply side' and then passed over a wall to 'the client'' (p. 498).

Certainly, client involvement is said to be important in achieving sustainable energy objectives and reducing CO_2 emissions (Ornetzeder and Rohracher, 2006; Heiskanen and Lovio, 2007). To Rohracher (2001), the functional dependency and complexity of the different components in sustainable buildings require close interaction among suppliers, professionals, clients and users for their successful construction (Rohracher, 2001). In addition, the client's clear appreciation of the 'value' of the technological development is seen to be paramount, particularly in the implementation of energy-efficient innovation (Intrachooto and Horayangkura, 2007). Indeed, the need for a clear client vision was emphasised by a number of studies (Cherns and Bryant, 1984; Barrett and Stanley, 1999; Ivory, 2004). Ivory (2004) underlines the importance of a strong and coherent 'customer vision' in enabling the client to fully realise project objectives. A well-motivated and cohesive client group can interact fully, and as an equal with the project team (Ivory, 2004).

In conclusion, the arguments above emphasise the importance of Client-Producer communication and collaboration for successful innovation. In the BSF PFI delivery model, BSF engagement processes are specifically designed to allow the ProjectCo and the Local Authority to discuss solutions, develop ideas, and explore options (PfS, 2006, 2008). Therefore, open communication and effective collaboration during BSF Local Authority-ProjectCo engagement processes can work to encourage SEI. The following proposition is forwarded:

> **Proposition 3:** SEI is supported by open communication and effective collaboration during BSF Local Authority-ProjectCo engagement processes.

4.2.4 Proposition 4: User-Producer Communication and Collaboration

The importance of users as partners in innovative processes was highlighted by various studies (Hobday, 1998; Gardiner and Rothwell, 1985; Lundvall, 1988; Reich *et al.*, 1996). Innovation processes in CoPS projects are often User/Producer driven and users are well integrated into the innovation process to ensure that designs meet their requirements (Hobday, 1998). The importance of user involvement was also highlighted by other system-oriented approaches to innovation management. Von Hippel's (1988) *Distributed Innovation Process Model* emphasises the role of users in driving innovation processes, particularly in providing the necessary information about their needs and the context on which the innovation would be used. To von Hippel (1988), users' motivation to engage in innovative activities rests on their ability to benefit from the result of the innovation. Lundvall's (1988) *Interactive Learning Theory* also identifies the need for users and producers to create dedicated channels and codes of information for the successful development of complex products. Freeman (1989) proposes that a mixture of professionals and non-professionals, working collaboratively, is the ideal context for successful innovation. Wynne (1988) similarly points out that closer interaction between users and technologists may help reduce the occurrence of technological failures. Edler *et al.* (2005) highlights the vital role played by users of innovative technologies in requirement identification. The major advantages of users' participation lie not only in developing requirements that are sufficiently clear to be delivered by producers, but also enabling successful application of the procured technology by the users in later stages (Edler *et al.*, 2005). It also determines users' 'readiness for change' (Clement *et al.*, 2009).

In the construction industry context, Slaughter (2000) argues that the complex 'multi-agent' nature of construction projects requires the collaborative efforts of key project actors, including users, to stimulate innovation. To Reich *et al.* (1996), the high risk and high cost involved in construction projects encourages users' participation in the design process as a means of reducing the risk of failure (Reich *et al.*, 1996). The benefit to the community was also highlighted by Reich *et al.* (1996) who argue that users' motivation to participate in innovation may be stimulated by the 'trace' or impact of the building on their community. The need for user involvement to take place as early as possible during the design process was highlighted by Atkinson (1999). Exploring partnership and empowerment in contemporary British urban regeneration, he observed that those affected by building programmes are often brought in late to the decision-making process after major planning decisions are already in place. Ivory (2004) also pointed out that users in construction projects often interact for a time-limited period with a single product. Contrary to mass-production where users may be involved in a number of iterations of the same product, users for construction products have a limited time to interact (Ivory, 2004). Moreover, the flexibility of the design and the ability of users to influence it diminish as the project progresses. Therefore, early involvement of users is critical for their effective contribution to the design process (Ivory, 2004).

Indeed, the need for effective user involvement for the successful implementation of sustainability innovation was highlighted by many studies (Barraclough, 1990; Paavola and Adger, 2002; Kaatz *et al.*, 2005; Rohracher, 2003, 2005). User involvement is seen to be mostly important for such innovations, which attempt to develop alternative and radically innovative solutions to realise users' requirements in a more environmentally-friendly manner (Heiskanen *et al.*, 2007). It was also found to be critical in successfully achieving sustainable energy objectives and reducing carbon emissions (Ornetzeder and Rohracher, 2006; Heiskanen and Lovio, 2007).

In summary, the preceding arguments support the proposition that User-Producer communication and collaboration is a key determinant of innovation. In the BSF PFI delivery model, effective involvement of BSF schools, as the ultimate users of the sustainable building, is thus, important for successful SEI. In fact, Senge (2000) and Mitchell (2008) emphasise that, for schools to be recreated, made vital and sustainably renewed, effective involvement is critical. This entails the engagement of schools in expressing their aspirations, building their awareness, and developing their capabilities (Senge, 2000; Mitchell, 2008). PFI guidance also stresses the importance of direct communication between designers and the ultimate end users (HM Treasury, 2000a; PfS, 2006, 2008). The BSF engagement process is specifically designed to allow the opportunity for sample schools to engage with bidders and provide detailed feedback on their developed design proposals (PfS, 2006, 2008). Therefore, open communication and effective collaboration during BSF School-ProjectCo engagement processes can work to support SEI. The following proposition is forwarded:

> **Proposition 4:** SEI is supported by open communication and effective collaboration during BSF School-ProjectCo engagement processes.

4.2.5 Proposition 5: Risk Allocation

It is inevitable that innovative endeavours will entail a certain amount of risk. Indeed, innovation and risk often go hand-in-hand in construction projects (Leiringer, 2003; Raisbeck, 2008; Barlow and Köberle-Gaiser, 2008ab). Construction project environments are mainly characterised by two types of risk: project risk and innovation risk (Leiringer, 2003). Project risk encompasses a wide range of categories all concerned with the possible events that could endanger the planned course or objectives of the project (HM Treasury, 1997; Jackson, 2004; Grimsey and Lewis, 2002; Rintala, 2004). Innovation risk is that faced by the innovating organisation in relation to the 'extent to which the innovation satisfies various technical criteria without increased cost of development, production or operation' (Leiringer, 2003, p. 95). Innovation risk includes a number of unavoidable risks such as financial risk (Souder and Bethay, 1993), technical risk (Hartmann and Lakatos, 1998) and ego risk (Bhidé, 2000). Project risk and innovation risk are interrelated and largely affect the outcome of the attempt to innovate (Leiringer, 2003).

The importance of contractual incentives for sharing project risks among the Client/User and Producer was highlighted by several CoPS innovation studies (Hobday, 1998; Miller and Lessard, 2000). The allocation of risk among project participants is also considered an important determinant of innovation success in construction projects (OECD, 2005; Raftery, 1994; Arndt, 2000; Akintoye *et al.*, 2001). Focusing on the PPP/PFI context, Leiringer (2006) maintains that greater clarity over the assumed risks, due to more explicit risk transfer under a PPP, might benefit innovative activities as it allows the innovating organisation to make rational decisions. Barlow and Köberle-Gaiser (2008b) also argue that the financial and legal uncertainty faced by the ProjectCo may be reduced by clear allocation of risk. In addition, Leiringer (2006) emphasises that the risks transferred should not only be considered clear, but also appropriate and manageable. Indeed, most government guidelines often use the maxim that risk should be allocated to the party best placed to control and manage it (UNIDO, 1996; HM Treasury, 2003). Blayse and Manley (2004) also underline the need for equitable allocation of risk among project participants.

Following the arguments above, it can be proposed that effective risk allocation can support SEI effort in the BSF PFI delivery model. The energy performance of buildings is associated with several types of risk such as regulatory, energy consumption and planning approval risks. For the ProjectCo to be innovative, the assumed risks associated with the project's energy performance should be considered clear, appropriate and manageable (Freeman and Soete, 1997; Barrett *et al.*, 2001;

Leiringer, 2006; Barlow and Köberle-Gaiser, 2008ab). Greater clarity over the assumed risks will allow the innovating organisation to make rational decisions, which may benefit innovative activities (Leiringer, 2006). Greater appropriateness and manageability will support the equitable allocation of risk among project participants, thus encouraging innovative efforts (UNIDO, 1996; HM Treasury, 2003; Leiringer, 2006; Barlow and Köberle-Gaiser, 2008b).Therefore, the following proposition is forwarded:

> **Proposition 5:** SEI is supported by clear, appropriate and manageable allocation of the risks associated with the project's energy performance.

4.2.6 Proposition 6: Reward Sharing Mechanisms

Many studies of CoPS, as well as construction innovation, emphasise the importance of mechanisms that enable the reward for innovation to be distributed according to the risk each party has assumed (Hobday, 1998; Winch, 1998; Barlow, 2000; Slaughter, 2000). Hobday (1998) maintains that clients/users of CoPS need to share risks and rewards with producers. Barlow (2000) recommends that financial mechanisms for sharing project risks and rewards are necessary to allow innovations to be well defined and to explain how costs and revenues are shared among project partners. Lenard and Eckersley (1997) and Oluwoye and Lenard (1999) also suggest that the level of innovation that occurs on construction projects is highly dependent on contractual incentives to encourage innovation. Incentive-based payments are often seen to encourage superior economic performance (Bayliss *et al.*, 2004; Tang *et al.*, 2006), time performance (Chua *et al.*, 1999), quality (Koehn and Datta, 2003), innovation (Dulaimi *et al.*, 2003; Caldwell *et al.*, 2009) and improved overall project performance (Olsen *et al.*, 2005). Winch (1998) argues that innovation where the client appropriates all the benefits is unlikely to take place (Winch, 1998). Winch (1998) proposes that incentives for innovation in construction projects can be enhanced by the adoption of gain-sharing mechanisms, where rewards are shared between the client and the project coalition (Winch, 1998). Key conceptual contributions also suggest that in order to encourage the supply-side to achieve exceptional results in terms of certain performance criteria, incentive-based payment should be linked to specific aspects of project objectives (Bresnen and Marshall, 2000b; Tang *et al.*, 2006; Eriksson and Westerberg, 2010).

Following from the above conceptual contributions, it can be proposed that contractual incentives on the PFI contract can work to support SEI. In the BSF PFI delivery model, the PFI Payment Mechanism is seen as the main method by which the client encourages the ProjectCo to maintain the quality of services at all stages of the contract, and ensures timely delivery. Therefore, adequate incentives in the BSF PFI Payment Mechanism linked to the project's improved energy performance can work to support SEI. The following proposition is forwarded:

> **Proposition 6:** SEI is supported by incentive-based payments linked to the project's energy performance.

4.3 Summary

The objective of this Chapter was to translate the study's first research question – ***What is the capacity of the PFI project delivery model to support the implementation of SEI on BSF new-build school projects?*** – into a conceptual framework and research propositions. The developed conceptual framework builds on Complex Product Systems (CoPS) theory and views the PFI project as an SEI supply network (Hobday, 1998). CoPS theory emphasises the collective and interactive characteristics of innovation in project contexts (Hobday, 1998, 2000; Hobday *et al.*, 2000; Gann and Salter, 2000; Davies and Salter, 2006). The conceptual framework proposes that the following three determinants of CoPS innovation are of particular importance to understanding SEI and should be considered as part of the explanation of the phenomenon:

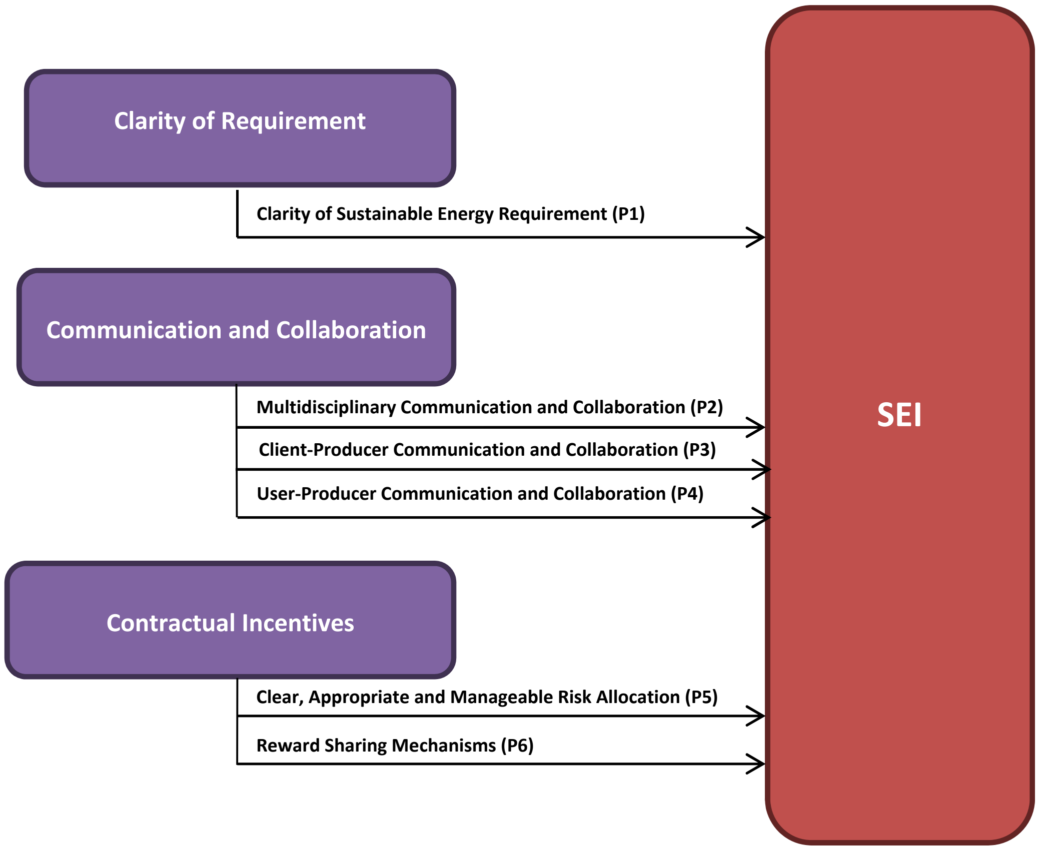
1. Clarity of the requirement (Hansen and Rush, 1998; Hobday and Rush, 1999; Ren and Yeo, 2006).
2. Communication and collaboration:
    i. Producers' multidisciplinary communication and collaboration (Miller *et al.*, 1995; Hobday, 2000; Brady *et al.*, 2005).
    ii. Client-Producer communication and collaboration (Gardiner and Rothwell, 1985; Miller *et al.*, 1995; Hobday, 1998).
    iii. User-Producer communication and collaboration (Hobday, 1998; von Hippel, 1988, 1998; Lundvall, 1988).
3. Contractual incentives:

i. Risk allocation (Hobday, 1998; Miller and Lessard, 2000).

ii. Reward sharing mechanisms (Hobday, 1998; Miller and Lessard, 2000).

Six conceptual propositions were developed based on theoretical concepts concerning factors that are critical for achieving innovation success derived from studies of CoPS, New Product Development and construction innovation. Figure 4.2 illustrates the conceptual framework.

Figure 4.2: The Conceptual Framework



Source: Developed for this research study

The study's first proposition focuses on the relationship between the clarity of the sustainable energy requirement in the BSF PFI delivery model and the SEI outcome. It proposes that SEI is supported by the greater clarity of the sustainable energy requirement and governing framework on the BSF PFI Output Specification. In CoPS projects, greater clarity of the requirement and governing framework is needed, as the main concern of an innovating organisation is the extent to which the innovation meets the criteria set by the particular context, without increasing development costs, production or operation (Leiringer, 2003).

The study's second proposition examines the relationship between multidisciplinary communication and collaboration in the BSF PFI delivery model and the SEI outcome. It puts forward that SEI is supported by open communication and effective collaboration within the integrated ProjectCo, particularly among design, construction, and operation disciplines. Indeed, In CoPS projects, innovative non-functional organisational structures are needed to coordinate production (Hobday *et al.*, 2000) and producers' main responsibilities are system integration and the management of multidisciplinary knowledge networks (Geyer and Davies, 2000; Davies and Brady, 2000). Effective communication and collaboration is nowhere more needed than in the development of sustainable buildings, as high levels of expertise are needed to deal with the complex problems of ecological optimisation (Rohracher, 2001; Anderson *et al.*, 2004; Intrachooto and Horayangkura, 2007). Therefore, open communication and effective collaboration among design, construction and operation disciplines within the integrated ProjectCo may bring together the expertise needed to manage the complexity of environmental design, and stimulate innovation (Ling, 2003; Caldwell *et al.*, 2009; Eriksson and Westerberg, 2010).

The third proposition explores the relationship between Client-Producer communication and collaboration in the BSF PFI delivery model and the SEI outcome. It advances that SEI is supported by open communication and effective collaboration during BSF Local Authority-ProjectCo engagement processes. Several studies in CoPS, New Product Development and construction innovation have highlighted the importance of client's involvement in successful innovation processes (e.g. Gardiner and Rothwell, 1985; Miller *et al.*, 1995; Mitropoulos and Tatum, 1999, 2000). Client involvement is seen to be particularly critical in achieving sustainable energy objectives and reducing CO_2 emissions (Ornetzeder and Rohracher, 2006; Heiskanen and Lovio, 2007). BSF engagement processes are specifically designed to allow the ProjectCo and Local Authority to discuss solutions, develop ideas, and explore options (PfS, 2006, 2008). Thus, open communication and effective collaboration during these engagement processes may support SEI.

Moreover, the study's fourth proposition draws attention to the relationship between User-Producer communication and collaboration in the BSF PFI delivery model and the SEI outcome. It puts forward that SEI is supported by open communication and effective collaboration during BSF School-ProjectCo engagement processes. The importance of users as partners in the innovation process was highlighted by various studies (e.g. Hobday, 1998; von Hippel, 1986, 1998, 2005; Lilien *et al.*, 2002), particularly in the case of sustainability and environmental initiatives on projects (e.g. Kaatz *et al.*, 2005; Ornetzeder and Rohracher, 2006; Heiskanen and Lovio, 2007). User involvement is said to be mostly important for such innovations, which try to develop alternative and radically innovative solutions to realise users' requirements in a more eco-efficient manner (Heiskanen *et al.*, 2007). The BSF engagement process is designed to allow the opportunity for sample schools to engage with bidders and provide detailed feedback on their developed design proposals (PfS, 2006, 2008). Open communication and effective collaboration during these engagement processes may stimulate innovation.

The following two sets of propositions draw attention to the importance of contractual incentives in supporting SEI. The study's fifth proposition examines the relationship between risk allocation in the BSF PFI delivery model and the SEI outcome. It proposes that SEI is supported by clear, appropriate and manageable allocation of the risks associated with the project's energy performance. Greater clarity over the assumed risks is said to allow the innovating organisation to make rational decisions, which may benefit innovative activities (Leiringer, 2006). Greater appropriateness and manageability will support the equitable allocation of risk among project participants, thus encouraging innovative efforts (UNIDO, 1996; HM Treasury, 2003; Leiringer, 2006; Barlow and Köberle-Gaiser, 2008b).

Finally, the sixth proposition explores the relationship between reward sharing mechanisms in the BSF PFI delivery model and the SEI outcome. It puts forward that SEI is supported by an incentive-based Payment Mechanism linked to the project's energy performance. Indeed, financial mechanisms that enable the reward for innovation to be distributed according to the risk each party has assumed is said to provide adequate incentive for innovation (Hawley, 1927; Barlow *et al.*, 1997; Winch, 1998; Barlow, 2000; Slaughter, 2000). Key conceptual contributions also suggest that in order to encourage producers to achieve exceptional results in terms of certain performance criteria, incentive-based payments should be linked to specific aspects of project objectives (Bresnen and Marshall, 2000b; Tang *et al.*, 2006; Eriksson and Westerberg, 2010). In summary, the study's propositions are as follows:

> **Proposition 1:** SEI is supported by the greater clarity of the sustainable energy requirement and governing framework on the BSF PFI Output Specification.

Proposition 2: SEI is supported by open communication and effective collaboration within the integrated ProjectCo, particularly among design, construction, and operation disciplines.

Proposition 3: SEI is supported by open communication and effective collaboration during BSF Local Authority-ProjectCo engagement processes.

Proposition 4: SEI is supported by open communication and effective collaboration during BSF School-ProjectCo engagement processes.

Proposition 5: SEI is supported by clear, appropriate and manageable allocation of the risks associated with the project's energy performance.

Proposition 6: SEI is supported by incentive-based payments linked to the project's energy performance.

The six conceptual propositions developed in this Chapter will be used as templates for data collection and analysis. The next Chapter will outline the research design and methodology used to collect the data to test the study's propositions.

Chapter 5: Research Methodology and Design

5.1 Introduction

This Chapter develops the research methodology to examine the implementation of Sustainable Energy Innovation (SEI) on BSF PFI projects. First, the Chapter positions the research study in its theoretical context. Second, it justifies the research design and the methodology used to meet the research objectives. Third, the Chapter develops the research design, including the research boundaries, data collection, and data analysis. Finally, the criteria for judging the quality of the research design involving the validity and reliability of the chosen case study approach are discussed.

5.2 Research Context, Paradigm, and Philosophical Position

The focus of this research is on PFI development processes where construction takes place. It can, therefore, be argued that this research is construction management research. Construction management research is a relatively new research discipline and it draws on a wide array of research methods, from both the social and natural sciences (Weihrich and Koontz, 1993; Fellows and Liu, 1997; Runeson, 1997; Raftery *et al.*, 1997; Wing *et al.*, 1998). Qualitative as well as quantitative data collection techniques are largely adopted and many different theories of knowledge or paradigms compete for methodological dominance (Dainty, 2008). There has been extensive debate over the most appropriate research method in construction management, and this debate has yet to reach a conclusion (Seymour and Rooke, 1995; Seymour *et al.*, 1997; Rooke *et al.*, 1997; Runeson, 1997; Harriss, 1998; Wing *et al.*, 1998; Seymour *et al.*, 1998; Raftery *et al.*, 1997; Lenard *et al.*, 1997). Raftery *et al.* (1997) provide a useful contribution when advising that construction researchers should undertake research by defining the problem and then applying the most appropriate method chosen from an unrestricted and wide range of possible approaches.

A fundamental step in establishing the most appropriate method for a research study is to understand the research paradigm and philosophical assumptions on which the study is rooted. Bryman (1988) defines a research paradigm as 'a cluster of beliefs and dictates which for scientists in particular discipline influence what should be studied [and] how research should be done' (p. 4). A research paradigm encompasses the ontological and epistemological foundations and assumptions that govern a particular study (Guba, 1990). These, in turn, influence the research methods used to investigate a problem and to collect, analyse, and interpret data (Dainty, 2008). As Dainty (2008) argues, adopting the view that research methods and research paradigms are interrelated will '... enable philosophical differences in the role that theory plays in research to be viewed through the lens of methods employed by researchers' (Dainty, 2008, p. 4).

In philosophy, *ontology* largely refers to conceptions of reality. The investigation of ontological distinctions is a key aspect of the research process as it allows the researcher to explicitly reveal how their perceptions of human nature impact on the approach they consciously adopt to uncover social truths (David and Sutton, 2004). A distinction could be made between *realist* ontology in which reality is given independent of the observer (Burrell and Morgan, 1979, Easton, 2002; Mingers, 2004) and *constructivist* ontology which is built on the belief that there is no observed phenomenon without an observer (Adler, 1997; Price and Reus-Smit, 1998; Ruggie, 1998; Wendt, 1999; Zelić and Stahl, 2005). This research study adopts the *constructivist* approach in that it views reality as the result of human perception which forms the phenomena under investigation (Zelić and Stahl, 2005). The approach also 'acknowledges the legitimacy and reality of differing perspectives on social phenomena' (Zelić and Stahl, 2005, p. 2). Taking a constructivist approach, the implementation of SEI is seen as a social construction built up from the actions and perspectives of social actors (Bryman and Bell, 2003). Indeed, to Cooke *et al.* (2007), making decisions on energy efficiency is a social process and highly contextual, thus strongly affected by the perceptions of project actors and unique project characteristics. Therefore, this research study holds the view that the implementation of SEI cannot be seen objectively; rather they are created, invented, and constituted in their social context during the process of design, development, and use (Zelić and Stahl, 2005).

In addition, e*pistemology* relates to what should be considered as acceptable knowledge in a discipline. A distinction could be made between *positivist* epistemology, which believes that the methods of the natural sciences should be applied to the study of social phenomena (Halfpenny, 1982; Turner, 1985; Becker and Niehaves, 2007), and *interpretivist*, which sees a phenomenon as having different subjective meaning for the actors studied (Weber, 2004; Walsham, 2006). Positivist epistemology is often linked to quantitative research approaches, while interpretive epistemology is largely qualitative. Quantitative research is generally based on the assumption that all social phenomena can be described or measured with a numerical system (McQueen and Knussen, 2002). It is characterised by the development of hypotheses, often drawn out of a literature review, that are subsequently tested. The data used to test these hypotheses is collected using, for example, questionnaires or interviews. Quantitative research is seen to offer great statistical advantages, particularly as it allows large amounts of data to be collected and analysed in a logical and replicable way (Fellows and Liu, 1997; Amaratunga and Baldry, 2001). Qualitative research, on the other hand, is often used in the exploration of a subject area in which only a limited amount of knowledge exists. The objective of qualitative research is to collect and analyse information from which new knowledge can be inducted. The objects of this type of research are usually people and their perceptions. Qualitative research is sometimes referred to as 'hypothesis generating research'. This follows the fact that qualitative research should precede quantitative research (Fellows and Liu, 1997; Amaratunga and Baldry, 2001). Burns (2000), as shown in Table 5.1, identifies and effectively compares key research methods used in both approaches.

Table 5.1: The Distinction between Qualitative and Quantitative Research Approaches

Qualitative	Quantitative
Assumptions	
Reality socially constructed	Facts and data have an objective reality
Variables complex and interwoven; difficult to measure	Variables can be measured and Identified
Events viewed from informant's perspective	Events viewed from outsider's Perspective
Dynamic quality to life	Static reality to life
Purpose	
Interpretation	Prediction
Contextualisation	Generalisation
Understanding the perspectives of others	Casual explanation
Method	
Data collection using participant observation, unstructured interviews	Testing and measuring
Concludes with hypothesis and grounded theory	Commences with hypothesis and theory
Emergence and portrayal	Manipulation and control
Inductive and naturalistic	Deductive and experimental
Data analysis by themes from informants' descriptions	Statistical analysis
Data reported in language of informant	Statistical reporting
Descriptive write-up	Abstract impersonal write-up

Source: Coley (2008) based on Burns (2000)

This research study is taking an interpretivist epistemological view in that it considers the implementation of SEI as having different subjective meaning for the actors studied. Geertz (1973) summarised an interpretive view of data collected in the following memorable sentence:

> 'What we call our data are really our own constructions of other people's constructions of what they and their compatriots are up to' (Geertz, 1973, p. 9).

The research study is also largely exploratory, in which only a limited amount of knowledge exists. The possible factors that influence the implementation of innovation, and in our case SEI, are large, complex and interwoven and thus are difficult to measure. Therefore, a qualitative approach was considered the best-suited for the study. Williamson (2002) also notes that interpretivist approaches are associated with inductive reasoning. Induction is a method of developing theory by identifying patterns of relationships among constructs within and across cases and their supporting logical arguments (Arbnor and Bjerke, 1997; Eisenhardt and Graebner, 2007). Hence 'Inductive reasoning is associated with the hypothesis generating approach to research' (Williamson, 2002, p. 27). Another significant advantage of qualitative approaches is that they enable more diversity in responses and the ability to adapt to new developments or issues during the course of the research study (Williamson, 2002).

5.3 Research Methodology

Within qualitative research, Robson (2002) identifies three influential design traditions: grounded theory, ethnography, and case study. Yin (2003) argues that the choice of appropriate research strategy depends on the research question that needs to be answered, the researcher's control over the phenomenon studied, and whether the phenomenon studied is contemporary or historical. Similar to Yin (2003), Chew (2001) argues that case studies are best suited for research questions when the researcher attempts to understand complex present-day events in situations over which the researcher has little or no control. Behrend (2005) also adds that case study methodology is suitable for examining projects when the researcher has neither control over the behaviour and dynamics of the teams involved nor over the boundary-spanning organisational situations. This distinct advantage of case study research seems to resonate with this research study.

Yin (1993) identified three specific types of case studies: *Exploratory*, *Explanatory*, and *Descriptive*. *Exploratory* case studies are regarded as an introduction to social research (Tellis, 1997). Fieldwork and data collection can be conducted before the research questions and hypotheses are defined. However, the theoretical framework must be created beforehand. *Explanatory* cases, on the other hand, are suitable for causal investigations (Tellis, 1997). Finally, *Descriptive* cases require a descriptive theory to be developed before starting the project and the formation of hypotheses of cause-effect relationships. This research study will be based on *exploratory* case studies. An explorative case study would allow the researcher to observe assumptions in the literature while remaining open to new explanations and evidence (Fong, 2003). It is, as Pettigrew (1990) explained, 'an explicit attempt to interpret the narrative but also to link emerging conceptual and theoretical ideas inductively derived from the case both to stronger analytical themes within the case and wider theoretical debates in the literature' (p. 280). The case study methodology is considered the best approach in exploratory research for its ability to examine real life situations and provide a rich insight into a research object (Miles and Huberman, 1994; Flyvbjerg, 2006). The case study can also be used to explore and fully describe the meaning of a certain phenomenon in its environment instead of through statistics and frequencies (Eisenhardt, 1989). For Yin (2003), case studies can satisfy the three principles of the qualitative method: describing, understanding, and explaining (Yin, 2003). The exploratory nature of this research study is, therefore, suitable for case study research.

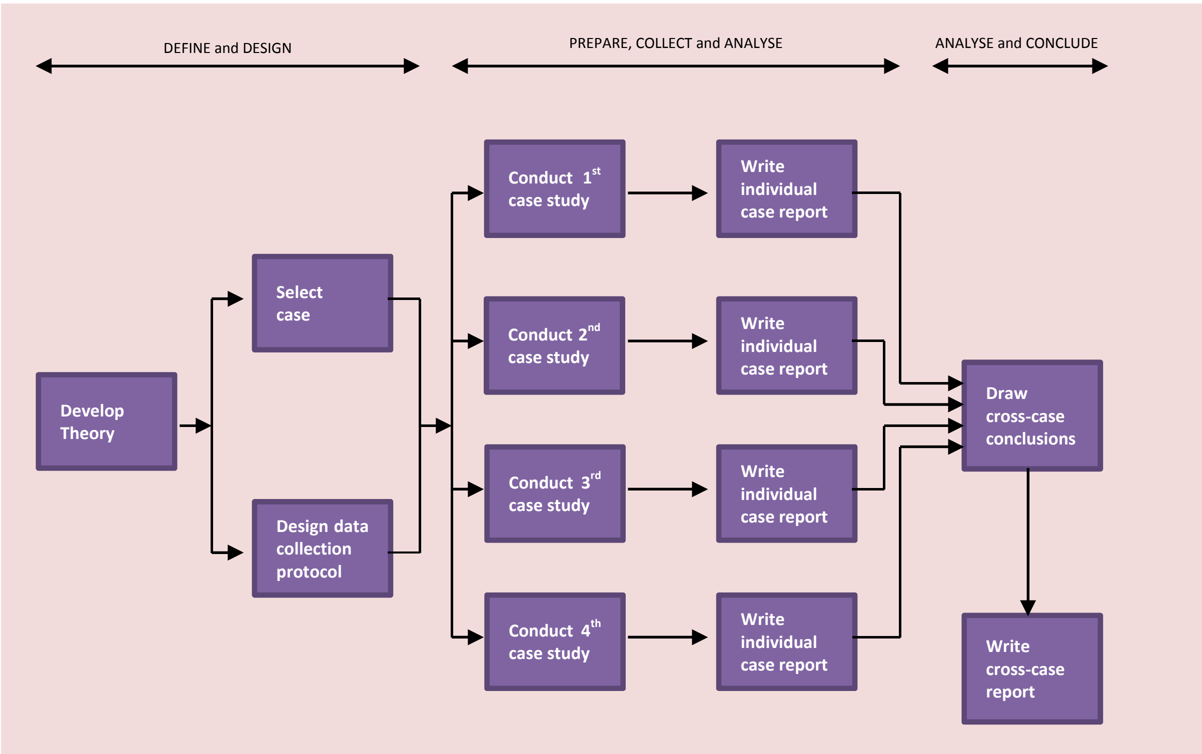
However, the case study research has been a subject of criticism. The two main sources for this criticism are that case study research is: (1) not representative, i.e. a case could not be regarded as representative for the whole issue that constitutes the object of the study; and (2) is biased, i.e. subjectivity can be introduced to the investigation by both the researcher and potential field informants (Hamel *et al.*, 1993). Eisenhardt (1989, 1991) and Yin (2003) acknowledge these criticisms and instead recommend a different approach to the case study. Two major interconnected requirements that must be fulfilled for the case study to answer these criticisms are identified – the study should be theoretically grounded and must have a research design. As Hartley (2004) points out, research design is 'the argument for the logical steps which will be taken to link the research question(s) and issues to data collection, analysis and interpretation in a coherent way'. Yin (2003) recommends that a case study design should be put in place to ensure that a predetermined procedure of inquiry is established. It is suggested that the case study design should include at least the following five components:

- A study's questions
- Its propositions
- Its unit(s) of analysis
- The logic linking the data to the propositions
- The criteria for interpreting the findings (Yin, 2003).

Yin (2003) maintains that the definition of the study's questions is the first task of the researcher. The study's propositions are helpful in focusing the study's goals. Indeed, in exploratory case study research, the adopted theory needs to be presented through propositions (Yin, 2003). As Rowley (2002) argues, researchers adopting the case study research method have to make a speculation, on the basis of the literature, as to what they expect their research findings to be. The data collection and analysis can then be organised in order to support or contest the research propositions (Rowley, 2002). The unit of analysis defines what the case is. This could be groups, organisations, or countries, but it is the primary unit of analysis. Linking the data to propositions and interpreting the findings are the least developed aspects in case study research (Yin, 2003).

This research study adopts the approach to case study research presented by Yin (2003) as explained in Figure 5.1 below.

Figure 5.1: Case Study Design



Source: Developed for this research based on Leiringer (2003) and Yin (2003)

5.4 Case Study Design

5.4.1 Case Study Boundaries

Qualitative researchers often struggle with the question as to what a case is and where its boundaries are (Miles and Huberman, 1994). Scott (2000) argues that the determination of boundaries in a research project is the outcome of a theoretically informed decision about what is *significant* in the situation under investigation. By clearly stating the unit of analysis at the very outset of the enquiry the study becomes more focused and the possibility of obtaining pertinent data improves (Yin, 2003). Leiringer (2003) also adds that a well-defined unit of analysis streamlines the enquiry, (e.g. the type of documents to be reviewed and the people/organisations to be considered as part of the investigation). This is particularly important when a multiple-case study is performed as it enables consistency across the cases (Leiringer, 2003). Within the context of this research, a case is defined as a formally documented BSF PFI construction project. The BSF PFI project involves several organisational groups or project partners, striving to achieve the agreed project goals in a boundary-spanning environment (Behrend, 2005). Styhre *et al.* (2004) argue that each construction project constitutes a temporal, reasonably bounded, isolated entity that can be regarded as a case for analysis.

5.4.2 Number of Case Studies

This research study adopts a 'multiple case' design approach. Chew (2001) and Yin (2003) identify that a single case study approach is suitable only when the following three criteria are met: (1) a critical case; (2) a unique/extreme case, and (3) a revelatory case in which it is possible to observe phenomena previously inaccessible to scientific investigation. The nature of the issues explored on this research does not justify the use of a single case study. The findings from the first three stages in the research design (Chapter 1, Section 1.8) clearly indicate that the pursuit of SEI within BSF PFI projects is common enough for the phenomenon not to be labelled rare or highly unusual. Moreover, a multiple case study approach is preferred over a 'single case' design approach because of the following key points:

- Multiple cases provide the capacity to handle the complex phenomena under investigation (Eisenhardt, 1989; Yin, 2003).

- Multiple cases provide triangulation of evidence, data sources, and research methods for more rigorous research (Eisenhardt 1989; Yin, 2003).
- Multiple cases strengthen the results by replicating the pattern-matching, thus increasing confidence in the robustness of the theory (Yin, 2003).
- Multiple cases can be used for theory generalisation (Eisenhardt, 1989; Patton, 1990) as well as for theory-testing through literal and theoretical replication (Eisenhardt, 1989; Bonoma, 1985).

In the same context, Yin (2003) advises that multiple cases should be regarded as 'multiple experiments' and not 'multiple respondents in a survey', thus *replication logic* rather than *sampling logic* should be used. Replication logic stands in contrast to sampling logic when a number of respondents are assumed to represent a larger population, thus, the data collected from a smaller number of persons '… are assumed to reflect the entire universe or pool' (Yin, 2003, p.56). Sampling logic is inappropriate for case studies, because cases are not intended to assess the incidence of phenomena and because sampling logic would entail the production of a huge number of cases, as the researcher attempts to cover both the phenomena and their context (Yin, 2003). Therefore, a multiple case approach based on replication logic is adopted as it has several advantages over a single case study design and is considered to be best suited to achieving the study's objectives.

The question of how many cases a research study should contain remains disputed. Perry (1998) highlights two groups of researchers with distinctly different positions. The first group refrains from proposing a number and recommends the decision be left to the researcher (Romano, 1989). Patton (1990) claims there are no set rules for sample size in qualitative research. Eisenhardt (1989) urges that cases should be added until 'theoretical saturation' is reached. Guba and Lincoln (1994) advocate sampling selection 'to the point of redundancy'. The second group of researchers, however, is more specific on the number of cases to be used. For example, Hedges (1985) sets an upper limit of 12 cases because of the high costs involved in qualitative interviews and the quantity of qualitative data that can be effectively assimilated. Miles and Huberman (1994) argue that more than 15 cases make a study 'unwieldy'. Perry (1998) proposes that an acceptable range of cases may fall between a minimum of 2 to 4 and a maximum of 12 to 15. On this research study, given the limited resources and time constraints faced by the researcher, a research design based on four case studies was considered to be both sufficient and practical.

5.4.3 Case Study Selection

The unit of analysis in this research study is predominantly the new-build BSF PFI project. However, the nature of these projects together with the aims and objectives of the research study need further refinements. Therefore, the following criteria were developed to guide the choice of appropriate construction projects to be included in the study:

- ***Criterion 1:*** The project should be part of the Local Authority's 'sample' schemes. Therefore, the project should be among the initial projects that the Local Authority went to market with when procuring its BSF programme. This was decided to ensure the project followed the typical BSF PFI development process outlined in Chapter 3 section 3.4.

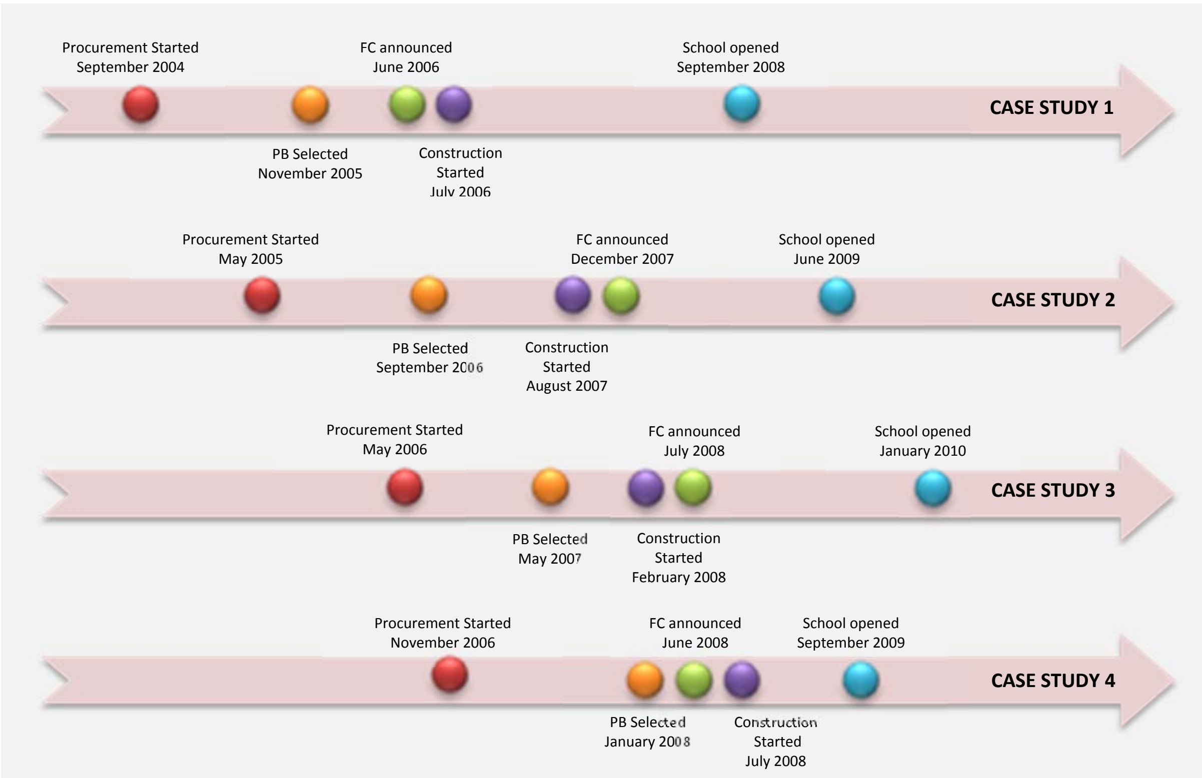
- ***Criterion 2:*** The project must include evidence of implementing SEI. This was the criterion in selecting three of the case studies, where literal replication will be sought. The fourth case study selected included no evidence of SEI. This was to allow theoretical replication to be tested. The three innovative projects were Brislington Enterprise College-Bristol City Council (Case Study 1), Highbury Grove School-London Borough of Islington (Case Study 2) and Big Wood School-Nottingham City Council (Case Study 4). The project that showed no evidence of innovation was Soar Valley College-Leicester City Council (Case Study 2). Identifying projects with evidence of implementing SEIs was challenging. Extensive review of national press and trade journals was undertaken to verify the nature of the solutions implemented and whether or not they could be considered innovative. In addition, so as to confirm the findings arising from the interview data, the case study projects and their SEIs' solutions were described to an independent Heating and Ventilation (HV) design expert. The expert was also provided with the design specifications of the SEIs. This confirmed that the SEIs implemented could be considered a novel change from standard practice.

- ***Criterion 3:*** To control as much as possible for the impact of contextual factors on innovation outcomes, the four case studies were selected from Wave 1 and Wave 2 BSF schemes. This is to make sure that the projects were subjected to the same policy and economic environment, and followed the same BSF documentation and national legislation. This was the case with the first three case studies, which is expected to offer insight into how the BSF PFI project delivery model, as it was during this initial period, influenced the pursuit of SEI. Case Study 4 further benefited from the introduction of the government's Carbon Funding and was awarded the extra funding of £50/m^2 to meet the operational carbon target of 27Kg CO_2/m^2/yr. This case study may present a special regulatory context and was included to maximise what could be learned from the research study. In addition, the four projects are recent projects, to account for both memory retrieval problems in the analysis of past events (Larsson, 1993) and industry-specific development cycles (Behrend, 2005). At the time data collection was conducted, between April 2009 and May 2010, three of the case study projects, i.e. Case Studies 2, 3 and 4, were on-site when the researcher established first contact with the projects. Case Study 1 was operational for a few months.

- ***Criterion 4:*** To encompass the perspective of a wide array of industry stakeholders, the four projects should involve different ProjectCo partners. This criterion was the most difficult and time-consuming to meet, given the small number of firms involved in the PPP/PFI market.

Following the criteria listed above, four BSF projects were selected. Table 5.2 (Page 119) provides an outline of the projects included in the study. It should also be noted that the case studies are organised and presented in a chronological order in the case study presentation chapters (Chapters 6 to 9). Figure 5.2 illustrates the development timelines of the four case study projects.

Figure 5.2: Development Timeline of the Four Case Study Projects



Source: Developed for this research study

Table 5.2: The Case Study Projects

	Case Study 1	Case Study 2	Case Study 3	Case Study 4
				
School:	Brislington Enterprise College (BEC)	Soar Valley College (SVC)	Highbury Grove School (HGS)	Big Wood School (BWS)
Local Authority:	Bristol City Council	Leicester City Council	The London Borough of Islington	Nottingham City Council
Region:	South West England	East Midlands	South East England (London)	East Midlands
BSF wave:	Wave 1- Pathfinder	Wave 1	Wave 2	Wave 2
Total BSF programme cost:	£133m	£235m	£140m	£222m
School Type:	Business and Enterprise status, 'schools within-a-school' model learning environment	Comprehensive with maths and computing specialism	Comprehensive	Business and Enterprise College
School Size:	1800 Pupils	1275 pupils	1350 pupils	750 pupils
Location:	Brislington – Bristol	Humberstone – Leicester	Highbury West Ward – Islington	Warren Hill – Nottingham
Site Type:	Site of existing school	Site of existing school	Site of existing school	Site of existing school
Total Value:	£34m	£21.5m	£30m	£20m
Procurement Start Date:	September 2004	May 2005	May 2006	November 2006
PB selected:	November 2005	September 2006	May 2007	January 2008
FC announced:	June 2006	December 2007	July 2008	June 2008
Construction started:	July 2006	August 2007	February 2008	July 2008
School Opening Date:	September 2008	June 2009	January 2010	September 2009
Awards:	The school was the winner of the 'Best School Team' award and highly commended in the 'Best Design for a New School' category in the national 2008 Excellence in BSF awards	The school was shortlisted in the 'Most Inspirational Use of Outside Space' category in the national 2009 Excellence in BSF Awards	The school was the runner-up in the 'Most Sustainable School Design' category in the national 2008 Excellence in BSF Awards	The school was shortlisted in the 'Best Design for a New School' category in the national 2009 Excellence in BSF awards. The LEP (inspiredspaces – Nottingham Ltd) was the winner of the 'Local Education Partnership of the Year' category in the national 2009 Excellence in BSF Awards.

Source: Developed for this research study

5.5 Data Collection

The following sections describe and discuss the main data collection process. First, the different sources of data will be identified and the case study interview participants outlined. In a second step, the case study interview protocol will be explained.

5.5.1 Sources of Data

The literature identifies at least six sources of evidence in case study research. Table 5.3 outlines these data collection methods, their sources, strengths, and weaknesses. It is necessary to understand that not all data sources are applicable to all case studies (Yin, 2003). The investigator should be able to handle all these sources of evidence where it would be necessary, but each case will present different options for collecting data (Yin, 2003).

Table 5.3: Sources of Data

Data Collection Methods	Sources	Strengths	Weaknesses
Documents	Letters, memorandums, agendas, administrative documents, newspaper articles, etc.	Triangulate evidence by corroborating the evidence from other sources useful for making inferences about events	May lead to false leads in the hands of inexperienced researchers
Archival records	Records, organisational records, lists of names, survey data etc.	Triangulate evidence	Accuracy issues
Interviews	Open-ended, focused, and structured or survey	Most important sources of case study information	Expensive, time-consuming
Direct observation	Field visit, could be as simple as casual data collection activities, or formal protocols to measure and record behaviours	Useful for providing additional information about the topic being studied	Researcher must not be intrusive
Participant-observation	The researcher becomes an active participant in the events being studied	Provides some unusual opportunities for collecting data	Researcher could alter the course of events as part of the group
Physical artefacts	Could range from tools, instruments, or some other physical evidence that may be collected during the study as part of a field visit	Researcher perspective can be broadened as a result of the discovery	-

Source: Developed for this research study based on Yin (2003), Stake (1995), Tellis, (1997) and Glesne and Peshkin (1992)

Data collection for this research study is largely based on primary data, thus 'data gathered and assembled specifically for the research project at hand' (Zikmund, 2000). The *unit of analysis* in this research study is the BSF PFI project and the key project stakeholders involved serve as the primary sources of data. Building on Kumar *et al.* (1993), Miles and Huberman (1994), Wilson and Vlosky (1997), and Yin (2003) the necessary primary data is gathered from in-depth interviews, semi-structured interviews, and case-related documents. The study involved a review of a variety of documents regarding BSF sustainability initiatives, Strategy for Change (SfC), Outline Business Cases (OBC), Strategic Business Cases (SBC), and Final Business Cases (FBC). Other documents that were gathered and studied are: project evaluation reports, design documents, information leaflets, project plans, and project schedules. The national press and industry journals have been examined to verify that the identified innovations were indeed to be considered an SEI. This triangulation of data, i.e. the use of multiple sources of data to search for empirical models that are supported by the different sources, contributes to the confirmability of the research results (Behrend, 2005). Neumann (2000) also argues that multiple sources of evidence increase the sophisticated rigour of the data collection and analysis and display the richness and diversity of the social environment under study.

5.5.2 Interview Participants

Data collection for this research study, as we have mentioned above, is based on primary data gathered from key project stakeholders. Data collection involved Local Authority, ProjectCo and School representatives. This ensured triangulation and increased the validity of the research findings. In order to ascertain key actors within each stakeholder group, the study benefitted from Dair and Williams' (2006) identification of key stakeholders influencing the development of sustainable brownfield sites. Applying the identification to BSF PFI project context, the following key actors were selected as key sources of data:

1. **Local Authority stakeholders:**
    - LA BSF Project Management Team
    - Local Authority Technical/Design Advisors
    - Local Authority Sustainability Unit
    - Local Authority Energy Management Unit
    - Local Authority Planners

2. **ProjectCo stakeholders:**
    - ProjectCo Bid Management Team
    - Architect
    - M&E Engineer
    - Building Contractor
    - Facility Manager
3. **School stakeholders:**
    - School BSF Engagement Team (SET)

Table 5.4 (Page 123) based on Dair and Williams (2006) and (Cabe, 2007ab) outlines the key stakeholders that may influence the implementation of SEI within the Local Authority, ProjectCo, and School. It also defines their role in relation to the achievement of sustainable energy. Based on the individual composition of each BSF PFI project and a comprehensive discussion with a key Local Authority/ProjectCo informant, the main players in each stakeholder team have been identified and selected as key interviewees within each case setting. Involving project participants in the research study was largely promoted through using key individuals with the Local Authority and/or the ProjectCo as high-level sponsors for the research. The number of key informants on each stakeholder team depended on the role of that stakeholder and the number of individuals identified as important contributors by other project members. At least one key individual was interviewed from each stakeholder team. In addition, when necessary, more interviews were conducted with members of the team to clarify any discrepancies. The definition of the number of interviews for each case study was guided by the need to obtain as much of a representative set of data as possible within the individual construction project. At least 12 interviews per individual BSF PFI construction project were considered adequate to ensure the desired information-richness of the case study (Behrend, 2005). A total of 50 interviews were conducted for this research study. Table 5.5 (Page 124) outlines the case study participants that took part on the research study. Appendix C provides more details on participants' job title, position in the organisation, the date, location, and type of interview. Data collection was carried out over a 13-month period between April 2009 and May 2010.

It should be noted that the key sustainability and energy expertise varied across the four Local Authorities. While the Local Authority sustainability expertise was represented by a sustainability unit and energy management unit on BEC (Case Study 1) and HGS (Case Study 3), on SVC (Case Study 2) the Local Authority did not have a sustainability unit or an energy management unit but an environmental team and a sustainability manager within the Education Department. On BWS (Case Study 4) the Local Authority did not have a sustainability or energy management unit at the time, and sustainability was largely driven by the BSF Project Management Team.

Table 5.4: Key Stakeholders in the Implementation of SEI on BSF PFI Project Development

Stakeholder	Role
The Local Authority Stakeholders:	
Local Authority BSF Project Management Team	The Local Authority BSF Project Management Team is responsible, on behalf of the Local Authority, for planning, monitoring and controlling all aspects of the project from inception through to completion. They coordinate, lead, and motivate the project team, which may include in-house staff as well as specialist consultants. Their role is to achieve the project aims on time and to the specified quality, cost, and performance standards.
Local Authority Technical and Design Advisors	The client design advisor acts from the inception of a BSF project through to its completion, performing a range of tasks to help ensure that the schools delivered are of the highest quality. Technical advisors coordinate the technical aspects of BSF projects. They advise on all the technical detail such as specifications and construction standards.
Local Authority Planners	Planners are responsible for the assessment of the short-term and long-term social, environmental, and economic impacts of development proposals in the context of the immediate locality and within the wider geographical area, and to advise on their suitability.
Local Authority Energy Management Unit	The Energy Management Unit is usually responsible for reducing energy consumption and carbon emission of the council’s properties. This usually includes the council’s offices, schools, and housing blocks. Energy Management Units’ activities may include the purchasing of the council's electricity from renewable sources and actively promoting a sustainable energy future for the city and its communities.
Local Authority Sustainability Unit	Local Authority Sustainability Unit is usually responsible for coordinating and promoting sustainability initiatives across the council and wider community.
The ProjectCo Stakeholders:	
The Bid Management Team	Bid Management Teams coordinate the different expertise needed to develop the ProjectCo bid. Within the constraints of land use, planning, consumer needs, and investor demands, they are the ones who are responsible for the delivery of the bid.
Architect	Architects design buildings, draw up master plans, and manage the implementation of projects. They have overall responsibility for the design and coordination of the input from the other members of the design team. Architects can provide advice on a wide range of issues from sustainable materials and energy-efficient buildings to consideration of the social and economic impacts of a development.
M&E Engineer	Buildings Services engineers are responsible for all heating, ventilation, and electrical systems in the building. They help to ensure that the environmental conditions in the building are good and can have a significant impact on the sustainability of the building.
Building Contractor	Contractors are responsible for the construction of the building. Under D&B contracts, the Building Contractor has the overall responsibility for the project and hires designers, consultants and subcontractors to perform various sub tasks.
Facility Manager	Facility Managers are responsible for the day-to-day running of the school. This often involves both ‘Hard’ maintenance (e.g. replacement of boilers or other fixtures and fittings) and ‘Soft’ facilities management services (e.g. catering and cleaning). They can play a key role in the energy-efficient operation of the building.
The School Stakeholders:	
School BSF Engagement Team (SET)	The team responsibility is to engage with bidders during the design process and provide detailed feedback on their developed design proposals. Schools, with the help of their advisors, evaluate the designs against their ambitions as set out at briefing stage.

Source: Developed for this research study based on Dair and Williams (2006) and (Cabe, 2007ab).

Table 5.5: Case Study Participants

Team	Case Study 1	Case Study 2	Case Study 3	Case Study 4
The local Authority:				
BSF Management Team (Core Team)	• Project Director • Technical/Design advisor	• Project Manager • In-house Technical Advisor	• Project Manager • Technical Advisor	• Design Manager • Technical Advisor • Sustainability Advisor
Planning Department	• Senior Planning Officer	• Senior Planning Officer	• Senior Planning Officer	• Principal Planning Officer
Sustainability Unit	• Sustainability Coordinator	• Sustainability and Low Carbon Building Officer • Sustainability Manager	• Head of Sustainability	-
Energy Management Unit	• Energy Management Officer	• Senior Energy Officer	• Energy Manager	-
The ProjectCo:				
Bid Management Team	• Bid Manager	• Bid Manager	• Assistant Bid Manager • Whole Life Cost Director	• Bid Director
Architect	• Project Director (Principal Architect) • Project Director (Development Architect)	• Project Director 1 • Project Director 2	• Project Director	• Project Architect
M&E Engineer	• Project Leader • Project Engineer	• Project Engineer	• Project Engineer	• Project Engineer
Building Contractor	• Design Manager	• Operations Manager	• Operations Manager	• Operations Manager • Education Director
Facility Manager	• General Manager	• Design Co-ordinator	• Operations Manager	• Contract Manager
Energy Consultant	-	-	-	• Project Manager
The School:				
School BSF Engagement Team (SET)	• School Principal	• School Business Manager	• School Head Teacher	• School Head Teacher
Number of interviews per case study	**13**	**13**	**12**	**12**
Total number of interviews	**50**			

Source: Developed for this research study

5.5.3 Case Study Protocol

The need for a case study protocol to improve the reliability of case study research is emphasised by many commentators (Yin, 1994, 2003; Stake, 1995; Perry, 1998; Tellis, 1997; Eisenhardt, 1989). Perry (1998) argues that a systematic and rigid tactic provides direction, which helps to improve the study's efficiency and focus. Yin (2003) recommends that a carefully designed case study protocol would include the following sections:

- Overview of the project (project objectives and case study issues being investigated).
- Field procedures (credentials and access to sites, sources of information).
- Questions (specific questions that the researcher must keep in mind during data collection).
- Guide for the case study report (outline, narrative form).

As Yin (2003) recommends, the overview should provide the reader with the general theme of the investigation and the subject of the case study. The field procedures are mainly concerned with data collection issues and must be well designed. As the case study researcher has no control over the data collection environment as in other research strategies, therefore, the procedures become increasingly important (Yin, 2003). Stake (1995) also advises that during interviews, which by nature are open-ended, the interviewee schedule must dictate the activity. In addition, Yin (2003) points out that issues such as access to the organisation in question, having enough resources in the field, clearly planning the data collection activities, and providing for unforeseen events, should all be considered and planned for in advance. The protocol will also enable the researcher to rigorously plan and document the information needed and procedures required for the data collection stage of the study (Eisenhardt, 1989). Table 5.6 (Pages 126-127) outlines the interview questions used to measure the study's key constructs. The developed qualitative measurements are adopted from previous studies of O'Reilly and Roberts (1976), Milgrom and Roberts (1992), Leiringer (2003), and Simatupang and Sridharan (2005). Appendix D presents the complete Case Study Interview Protocol adopted on this research study. Additional questionnaire items were included in the protocol to elicit contextual issues pertaining to the case study projects.

Table 5.6: Qualitative Measurement of Conceptual Constructs

Proposition	Concept	Key Construct(s)	Measurement	Corresponding Interview Question(s)
Proposition 1	Clarity of the client requirement	Clarity of the requirement (Heavisides and Price, 2001)	Participant's perception of the extent to which the sustainable energy requirement and governing framework are free from confusion, uncertainty, ambiguity, or doubt.	4.9. How would you describe the sustainable energy requirements in the Output Specification? Were they principally: a. Generalised statements about policy and regulations b. Technical type (defining the technical and physical characteristics of its items (e.g. CHP or Biomass boilers) c. Performance type (defining the environmental performance required) d. Mandatory outcome-based type (defining, for example, carbon emission targets) 4.10. Can you describe the degree of clarity of the sustainable energy requirement and governing framework in the Output Specification? To what extent the sustainable energy requirement and governing framework were free from confusion, uncertainty, ambiguity, or doubt? 4.11. Were there any aspects of the Output Specification and governing framework with which your organisation was not completely satisfied? How did this affect the sustainable and energy-efficient outcome of the project? 4.12. Do you have further comments on the standard BSF PFI Output Specification?
Proposition 2	Producers' multidisciplinary communication and collaboration	(1) Openness of communication (O'Reilly and Roberts, 1976).	Participant's perception of the extent to which his/her organisation/team has communicated directly with the other organisations/teams concerned during the design development process.	5.1.1. How direct was the communication between your organisation and the teams below during the design development process? a. The Bid Management Team b. The Architect c. M&E Engineer d. The Building Contractor e. The Facility Manager
		(2) Effectiveness of collaboration (Simatupang and Sridharan, 2005)	Participant's perception of the extent to which his/her organisation/team has worked jointly with the other organisations/teams concerned towards a common SEI goal.	5.1.2. How collaborative was the relationship between your organisation and the teams above towards a common SEI goal? 5.1.3. What kind of problems or difficulties did you have in relating to the above teams? How did this affect the sustainable and energy-efficient outcome of the project?
Proposition 3	Client-Producer communication and collaboration	(1) Openness of communication (O'Reilly and Roberts, 1976).	Participant's perception of the extent to which his/her organisation/team has communicated directly with the Local Authority's Sustainability expertise during the design development process.	5.2.1. How direct was the communication between your organisation and the following teams within the Local Authority during the design development process? a. The Core Team b. Sustainability Unit c. Energy Management Unit d. Planners
		(2) Effectiveness of collaboration (Simatupang and Sridharan, 2005)	Participant's perception of the extent to which his/her organisation/team has worked jointly with the Local Authority's sustainability expertise towards a common SEI goal.	5.2.2. How collaborative was the relationship between your organisation and the Local Authority's sustainability expertise towards a common SEI goal? 5.2.3. What kind of problems or difficulties did you have in relating to the Authority's sustainability expertise? How did this affect the sustainable and energy-efficient outcome of the project?

Cont. Table 5.6: Qualitative Measurement of Conceptual Constructs

Proposition	Concept	Key Construct(s)	Measurement	Corresponding Interview Question(s)
Proposition 4	User-Producer communication and collaboration	(1) Openness of communication (O'Reilly and Roberts, 1976).	Participant's perception of the extent to which his/her organisation/team has communicated directly with the School during the design development process.	5.3.1. How direct was the communication between your organisation and the School during the design development process?
		(2) Effectiveness of collaboration (Simatupang and Sridharan, 2005)	Participant's perception of the extent to which his/her organisation/team has worked jointly with the School towards a common SEI goal.	5.3.2. How collaborative was the relationship between your organisation and the School towards a common SEI goal? 5.3.3. What kind of problems or difficulties did you have in relating to the School? How did this affect the sustainable and energy-efficient outcome of the project?
Proposition 5	Risk allocation	(1) Clarity of risk allocation (Leiringer, 2003)	Participant's perception of the extent to which the allocation of the risks associated with the energy strategy is free from confusion, uncertainty, ambiguity, or doubt.	6.1. How clear was the allocation of the risks associated with the energy strategy on this project?
		(2) Appropriateness of risk allocation (Leiringer, 2003)	Participant's perception of the extent to which the allocation of the risks associated with the energy strategy is fitting for a particular entity or situation.	6.2. In your opinion, was the allocation of the risks associated with the energy strategy appropriate? What, if any, risks were non-negotiable? 6.3. Were there any specific risks associated with the energy strategy that should have been allocated differently? Do you think that the affected actors were/are clear over the risks that they were taking on?
		(3) Manageability of risk allocation (Leiringer, 2003)	Participant's perception of the extent to which the allocation of the risks associated with the energy strategy can be managed or controlled.	6.4. In your opinion was the risk allocated to your organisation manageable? 6.5. What were the most probable risks to materialise for your organisation? How did the innovation influence these probabilities? 6.6. What were the most probable risks to materialise for the project as a whole? How did the innovation influence these probabilities? 6.7. What were the most significant risks for your organisation should they materialise? When were you clear that you had to take those risks? How did the innovation impact (positive or negative) on the way you handled these risks?
Proposition 6	Reward sharing mechanisms	Incentives (Milgrom and Roberts, 1992)	Participant's perception of the extent to which the BSF PFI Energy Payment Mechanism is linked to incentives for improved energy performance.	7.1. Do you understand how the standard BSF PFI Energy Payment Mechanism operates? 7.2. How does the standard BSF PFI Energy Payment Mechanism impact on your organisation's incentive to provide a high level of sustainability and energy efficiency? 7.3. Do you have further comments on the standard BSF PFI Energy Payment Mechanism?

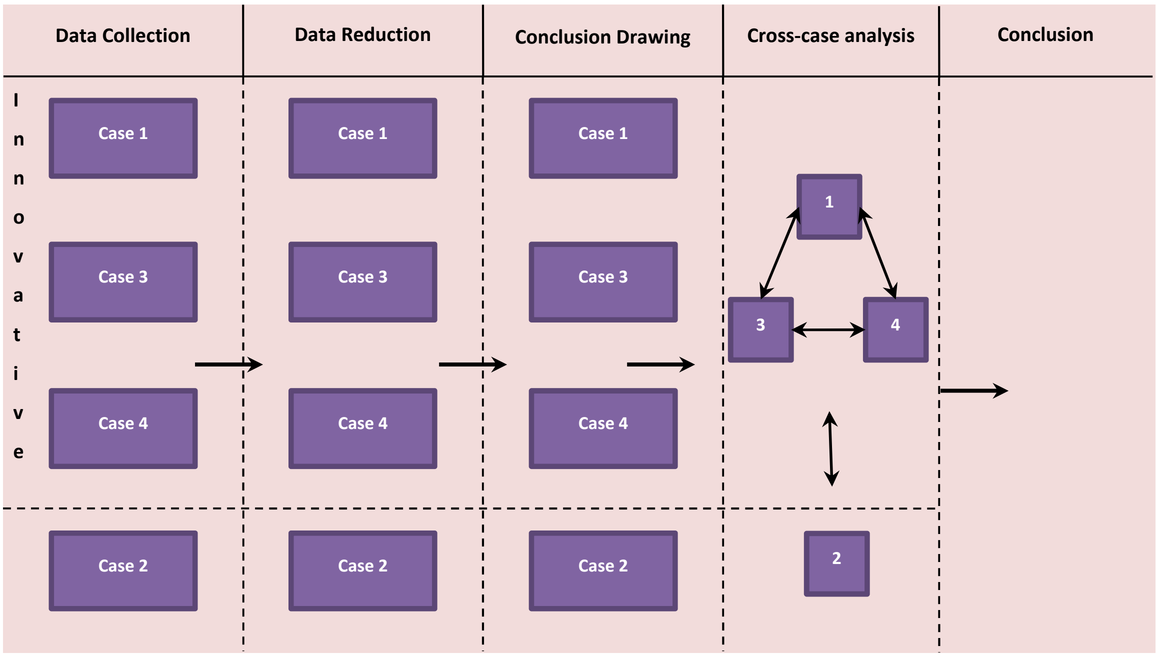
Source: Developed for this research study based on O'Reilly and Roberts (1976), Milgrom and Roberts (1992), Leiringer (2003), and Simatupang and Sridharan (2005).

5.6 Data Analysis

Yin (2003) recommends developing an analytical strategy towards preparing and conducting case study analysis and that this should be in place well before any information is collected. Rowley (2002) identifies that a case study database will typically include a multitude of different evidence from multiple sources. Analysis of such rich sources of data should be based on examining, categorising, and tabulating evidence to assess whether the findings confirm or falsify the initial propositions (Popper, 1959; Flyvbjerg, 2006). Rowley (2002) suggests an analytical strategy using the research propositions that encapsulate the study's objectives and which have shaped the data collection. The researcher will trawl through the evidence seeking corroboration or otherwise of the initial propositions, and then record relevant evidence and make a judgement on whether the positions have been substantiated.

The analytical strategy adopted in this research study combines the advice of Yin (2003) and Rowley (2002) in adopting an analytical strategy based on propositions as well as literal and theoretical replication. First, within-case analysis is based on propositions. The multiple sources of data from each case study were examined, categorised, and the evidence tabulated to assess whether the findings confirm or falsify the initial propositions (Popper, 1959; Flyvbjerg, 2006). In order to determine whether a proposition is supported or otherwise, we adopt the view of Popper (1959) and Flyvbjerg (2007) that a single non-supporting 'falsifying' occurrence can refute a proposition. Thus, if just one observation does not fit with the proposition, it is considered to be unsupported. Second, cross-case analysis is based on literal and theoretical replication. *Literal replication* in a case study tests precisely the same outcomes, principles, or predictions established by the initial case study. Thus, it must be selected so that it predicts similar results. In contrast, a *theoretical replication*, is a case study that produces contrasting results but for predictable reasons. Under the development of a conceptual framework, literal replication can explain the conditions under which a particular phenomenon is likely to be found, whereas a theoretical replication can explain the conditions when it is not likely to be found (Behrend, 2005). In this research study we aimed for literal replication between three innovative cases (Case Studies 1, 3, and 4) and theoretical replication in one further case (Case Study 2). Figure 5.3, adopted from Leiringer (2003), illustrates the relationships between the cases and the analytical strategy.

Figure 5.3: The Analytical Strategy



Source: Developed for this research study based on Leiringer (2003)

5.7 Research Validity

Four tests have been widely used to establish the quality of empirical social research: construct validity, internal, and external validity and reliability (Yin, 2003; Rowley, 2002).

Table 5.7: Qualitative Criteria for Case Study Research Design Evaluation

Criterion	Methodological tactics	Phase of research in which tactic occurs
Construct validity	Use prior theory Use multiple sources of evidence Establish chain of evidence	Research design Data collection Data collection
Internal validity	Do pattern-matching Do explanation-building Address rival explanations	Data analysis Data analysis Data analysis
External validity (analytical generalisation)	Use replication logic in multiple case studies	Research design
Reliability (Methodological trustworthiness)	Use a systematic data collection methodology (case study protocol) Develop case study database	Data collection Data collection

Source: Developed from Behrend (2005), Yin (2003), Healy and Perry (2000), and Teale (1999)

5.7.1 Construct Validity

Construct validity is concerned with the development of correct operational measures in order to test the theoretical concepts (Emory and Cooper, 1991; Yin, 2003). Criticism of the case study approach is often centred on the weakness of this aspect, leading to a tendency for subjective judgement to creep in during the data collection (Yin, 2003). Construct validity is made possible on this research study by using prior theory to measure the study's key constructs. The developed qualitative measurements are adopted from previous studies of O'Reilly and Roberts (1976), Milgrom and Roberts (1992), Leiringer (2003), and Simatupang and Sridharan (2005). Construct validity was also accomplished by using multiple sources of evidence and establishing a clear *chain of evidence* linking the research questions and propositions to the data collected. The case study protocol, including interview questions, is designed to achieve a structured approach to exploring the research issues and ensure a flowing pattern of questioning and adequate identification of data collected. All interviews are recorded and later transcribed. Interview transcripts are systematically organised, with sources of data carefully referenced during data analysis to achieve good quality research (Yin, 2003; Behrend, 2005). Triangulation is also attained by collecting data from multiple sources such as in-depth and semi-structured interviews, project reports, and web-based information. In addition, data collection involved ProjectCo, Local Authority and School representatives. This triangulation of data sources is seen to address the potential problems of construct validity as the different sources of evidence essentially provide multiple measures of the same phenomena (Yin, 2003). It also allows research findings to be based on a convergence of information from multiple sources (Leiringer, 2003). Data collection for each case study involved at least 12 interviews in order to capture information-rich perceptions of ProjectCo, Local Authority and School representatives within the investigated BSF PFI project.

5.7.2 Internal Validity

Internal validity is concerned about the correctness, reliability, 'truth value', and credibility of the study results (Yin, 2003; Miles and Huberman, 1994). In qualitative research, cause-and-effect internal validity is usually a minor concern because qualitative research attempts to identify 'what' the variables involved in phenomenon are and leaves causal relationships between the variables to later quantitative research (Behrend, 2005; Zikmund, 2000; Yin, 2003). However, Behrend (2005) argues that internal validity is still necessary on qualitative approaches to minimise ambiguity and contradiction. Establishing a clear tactic to increase internal validity in qualitative research is difficult but, Yin (2003) recommends pattern-matching and addressing rival explanations before drawing conclusions from inferences.

In this research study, the strategy adopted is based on pattern-matching logic, i.e. the empirically derived pattern is compared to a theoretical pattern predicted. Based on the literature review developed in Chapters 2 and 3, Chapter 4 identified three CoPS innovation determinants that may explain the innovative phenomenon on BSF PFI projects. Six propositions were consequently developed, based on extensive review of innovation theory. These propositions are to serve as the predicted patterns against which the data from the four case studies are to be compared (Leiringer, 2003).

5.7.3 External Validity

External validity relates to whether the study's findings are generalisable beyond the immediate case study (Yin, 2003). In case study research, analytical generalisation is attained through replication logic utilising multiple case studies. In addition, external validity is also achieved by the comparison of the research evidence with extant literature (Eisenhardt, 1989). In this research, multiple case studies are used to achieve analytical generalisation by applying both literal and theoretical replication logic. The replication approach adopted on this research study is outlined in section 5.6. The study is based on three projects that were evidence of SEI being present. Cross-case analysis will examine the degree of literal replication among the case studies. A fourth case study with no evidence of SEI is also studied to allow theoretical replication to be undertaken. The findings from the theoretical and analytical replication will subsequently be combined and final conclusions reached. A comparison of the research findings to the extant literature will further facilitate the necessary analytical generalisation in this study (Miles and Huberman 1994; Yin, 2003; Behrend, 2005). It will also allow the development of recommendations, based on theory as well as a priori reasoning, to remedy the identified problematic issues faced by firms in implementing SEI.

5.7.4 Reliability

Reliability, sometimes termed 'methodological trustworthiness' examines the extent to which the study will produce similar findings if repeated (Emory and Cooper 1991; Zikmund, 2000). High reliability indicates that similar results will be obtained if the techniques and procedures used to collect data remain constant throughout the repeated research (Yin, 2003). Yin (2003) recommends strategies to ensure a high degree of reliability, i.e. to develop a case study protocol in the research design phase, use this protocol to collect data, and develop a case database during the data collection phase. Therefore, in this research study, three measures to ensure reliability are used. First, a case study protocol was developed in the research design phase in order to ensure consistency of procedures across the case studies. Second, this protocol formed the basis for data collection. All interviews were recorded and later transcribed. Third, a case study database was created in which the transcribed interviews and any collected documents were included and kept up to date for the researcher to access when needed (Yin, 2003).

5.8 Summary

This Chapter developed the research methodology to examine the implementation of SEI on BSF PFI projects. First, the Chapter positioned the research study in its theoretical context. Second, it justified the research design and the methodology used to meet the research objectives. Third, the Chapter developed the research design, including the research boundaries, data collection, and data analysis. Finally, the criteria for judging the quality of the research design involving the validity and reliability of the chosen case study approach were outlined.

Chapter 6: Case Study 1

Image 6.1: BEC: Aerial view showing the new school (centre) and the old school (right)
Courtesy of Atkins (2009)

This Chapter presents the findings from Brislington Enterprise College (BEC) case study. The Chapter is divided into four sections. The first section provides a brief introduction to the project, the Sustainable Energy Innovation (SEI) implemented, and the project's sustainable energy design features. The second section outlines the key sources of data. The third section explores the case study findings based on the six propositions developed in Chapter 4. The fourth section offers a concluding summary of the case study's findings.

6.1 Introduction

BEC is one of four schools[3] in the first phase of Bristol City Council's £133m Building Schools for the Future (BSF) programme. It is a large £34m newly built Business and Enterprise College for 1800 pupils aged 11–16. It is the largest secondary school in the City of Bristol, serving the communities of Brislington, St Anne's, Broomhill, Totterdown, and Stockwood.

The new BEC development was part of Bristol's 'Sample' schemes. It, therefore, was one of four school projects the Council went to market with when procuring their BSF programme and was designed as part of a competitive dialogue process. Bristol City Council's OJEU notice was published in September 2004 and a Preferred Bidder was selected in March 2006. The Council's Preferred Bidder, Skanska Education Partnership, was a Consortium comprising Skanska Infrastructure Development/Barclays (Equity Providers), Skanska Construction (Building Contractor), Wilkinson Eyre Architects (Lead Design Partner), Skanska Rashleigh Weatherfoil (Facility Management) and Northgate Information Solutions (ICT). In June 2006 Financial Close was reached, creating the UK's first Local Education Partnership (LEP). Construction on site started in July 2006 and the School opened in September 2008.

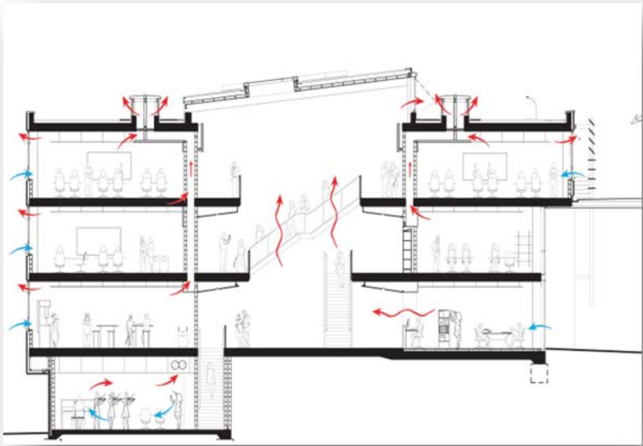


Image 6.2: BEC: Ventilation Strategy
Courtesy of Buro Happold/Flacq and Hufton and Crow (2010)

BEC was selected as a case study for its innovative ventilation chimney. The design utilises an innovative ventilation chimney in every classroom. The innovative chimneys provide outstanding cross air flow across the classrooms, minimising the need for mechanical ventilation (see Image 6.2 above). The School is also designed to 'Very Good' BREEAM rating and the design achieved 40% reduction in CO_2 emission (against Part L 2002 Building Regulation). The School's main sustainable energy design features are outlined in Figure 6.1.

[3] The other three schools are Hartcliffe Engineering College, Speedwell Technology College, and Whitefield Fishponds Community School.

Figure 6.1: BEC Sustainable Energy Design Features

Energy Efficiency:

- **Building Fabric:** Thermal mass is used to stabilise temperatures, reducing energy requirements. The school does not have a suspended ceiling and the concrete soffit is exposed to provide thermal cooling. Shafts running across the concrete soffit are used for services and acoustic buffers.
- **Lighting:** High levels of daylight are provided through the façade and roof-lights, and highly efficient lighting and sensor control systems are used to further reduce energy use. The rooms are designed with a minimum of 40% glazing according to their orientation. On south facing elevations solar control glazing is also utilised to reduce solar gain.
- **Ventilation:** A natural ventilation strategy is used with a variety of opening systems so users can have a high degree of control. Ventilation chimneys optimise air flow across classrooms, minimising the need for mechanical ventilation. Night-time cooling has been incorporated, and it deals with high summer temperatures. Mechanical ventilation that is necessary to some areas is centralised to maximise efficiency.

Renewable Energy:

- **Biomass Boiler**: Heating and hot water are supplied by a Biomass Boiler burning wood chip from a nearby forest. The biomass heating system aims to reduce heating-related carbon emissions by as much as 75% compared to a standard system. A Gas Boiler provides top-up.

The school design achieved 40% reduction in Co_2 emission (against Part L 2002 Building Regulation)

Source: Developed for this research study

6.2 Case study Participants

Data collection for this case study involved 13 semi-structured interviews with key project stakeholders. Table 6.1 lists the actors that took part in the research study. It describes each interviewee in terms of his/her respective organisational team and the interviewee position within the team (please refer to Table 5.4 in Chapter 5 for a description of how stakeholders were selected to be included in the study, including a description of their role and responsibilities). It also outlines the title used to refer to the interviewee within the case study findings.

Table 6.1: BEC Case Study Participants

Team	Interviewee	Title used to refer to interviewee within the case study findings	Ref.
The Local Authority: Bristol City Council (BCC)			
BSF Management Team	Project Director	LA BSF Project Director	L1
	Client Technical/Design Advisor	LA Technical/Design Advisor	L2
Planning Department	Planning Officer	LA Planning officer	L3
Sustainable City Team	Sustainability Coordinator	LA Sustainability Coordinator	L4
Energy Management Unit	Energy Management Officer	LA Energy Management Officer	L5
The ProjectCo: Skanska Education Partnership			
SEP Bid Management Team	Bid Manager	ProjectCo Bid Manager	P1
Building Contractor (Skanska Construction)	Design Manager	Building Contractor's Design Manager	P2
Principal Architect (Wilkinson Eyre)	Project Director	Project Architect (1)	P3
Development Architect (FLACQ)	Project Director	Project Architect (2)	P4
M&E Engineer (Buro Happold)	Project Leader	M&E Engineer (1)	P5
	Project Engineer	M&E Engineer (2)	P6
Facility Manager (Skanska RW)	General Manager	FM General Manager	P7
The School: BEC			
School Engagement Team	School Principal	School Principal	S1

Source: Developed for this research study

6.3 Case Study Findings

This section will present findings from BEC case study. The case study findings are divided into six subsections according to the six research propositions developed in Chapter 4. Table E1 in Appendix E reviews the key findings for each proposition. The table summarises emergent issues for each conceptual construct (defined in Table 5.6 of Chapter 5), synthesised from the 13 case study interviews, and demonstrates the theory underlying the empirical findings. Effort was made to tie the Box related to each theoretical construct clearly to the text. Each proposition subsection is also illustrated with quotes from the case study interviewees.

6.3.1 Proposition 1: Findings

The study's first proposition advances that SEI is supported by the greater clarity of the sustainable energy requirement and governing framework on the BSF PFI Output Specification. This section will discuss the extent to which this conceptual proposition translated into experienced reality in supporting the implementation of SEI during the design development stages of BEC. The case study findings will be discussed under three headings: (1) The development of the sustainable energy requirement; (2) Clarity of the sustainable energy requirement (Box E1.1.1); and (3) Clarity of the governing framework (Box E1.1.2).

1 The Development of the Sustainable Energy Requirement

Bristol City Council is a BSF 'Wave 1 Pathfinder' Local Authority. Bristol City Council BSF programme was managed by a BSF Management Team (referred to as the Core Team in the remainder of this Chapter) which included a Project Director, three project managers, two solicitors, and two administrators. The team was supported by external technical and design advisors. The team also appointed external advisors for legal and financial issues. The overriding objective of the BSF programme was to increase educational standards in the City of Bristol. The BSF programme was seen as an opportunity to break the cycle of educational underachievement in the City Council. One of the main priorities of Bristol City Council's BSF development was that school designs should promote the transformational agenda in the City. The new school buildings constructed under BSF were to provide intelligent designs of education accommodation that facilitate curriculum delivery and maximise the opportunities for students to reach their full potential (BCC, 2006).

While providing inspirational learning environments was the main objective of Bristol's BSF, the City Council saw the pursuit of a sustainable solution as an opportunity to showcase its commitment to the issue. Indeed, Bristol City Council has a longstanding corporate commitment to sustainability, which dates back to the 1990s. According to Bristol City Council BSF Final Business Case (FBC) (BCC, 2006), the City Council vision is:

> Bristol: A green capital in Europe—creating sustainable communities and
> improving the quality of life.

Therefore, while the overriding objective of the BSF programme was to increase educational standards in the City of Bristol, the Local Authority ensured that its sustainability aspirations and policies were supported. According to Bristol City Council FBC (BCC, 2006), if new school buildings were to serve their communities well for many years to come, it was essential that they are high quality, attractive buildings (BCC, 2006). Design quality 'encompasses a number of facets including sustainability, flexibility, adaptability and value for money' (BCC, 2006, p. 8).

To support the implementation of sustainability, the Core Team enlisted the help of the Council's in-house Sustainable City Team, responsible for coordinating and promoting sustainability initiatives across the Council and wider community. The Sustainable City Team was invited to take an active role in the BSF programme from its initial consultation stages and was heavily involved throughout. The Sustainable City Team advised the Core Team on sustainability issues and ensured that Bristol's environmental policies were supported in the Local Authority's Output Specification. The Sustainable City Team was involved in the visioning process, the writing of the sustainability requirement, engagement with bidders, as well as in bids evaluation.

Image 6.3: BEC: Outdoor Area
Courtesy of Buro Happold/Flacq and Hufton and Crow (2010)

However, as Bristol was one of the first pathfinder authorities, the BSF process was seen to be extremely complicated in comparison to the Local Authority's previous experience with construction projects. Indeed, Bristol was the first Local Authority in the UK to establish a Local Education Partnership (LEP) and, therefore, the process leading to this end was a steep learning curve to all involved. There were hardly any previous BSF schemes to advise the team. Bristol City Council was also undergoing corporate reorganisation at the time, and it was left for the Core Team to manage the BSF programme. Therefore, efforts seemed disjointed at times. Bristol Core Team also suffered a lack of continuity and capacity, with key members of staff being 'head-hunted' and leaving immediately after the establishment of the Bristol LEP to work with Partnership For School (PfS) and other organisations working within BSF.

The Sustainable City Team saw the early visioning process as an opportunity to engage with the schools involved and develop a school-specific vision for sustainability. However, sustainability as a requirement was not particularly high on the School's agenda, with educational issues dominating discussion. Also, the Sustainable City Team felt the early consultation period was tightly managed by the Core Team. The Sustainable City Team had limited communication with the schools during the consultation leading to the development of the Output Specification. The LA Sustainability Coordinator felt the consultation process could have benefited from open consultation with professional facilitation. The Sustainability Coordinator attributed this lack of open consultation to the project management mentality of the Core Team and their focus on freezing the design early to reduce risk exposure. This consequently limited the exploration-side of the consultation and restricted the ability of stakeholders to appraise different sustainability options. As the Sustainability Coordinator commented:

> I think they [*referring to the Core Team*] are in a kind of different world really. They are in a kind of project management world where all the emphasis on project management is you freeze the specification very early on so you get rid of all the uncertainty that could bring risk and cost at a later date and that prevents you from thinking: 'Well what if we went on a mini bus to look at that sustainable School in Cheshire?' (LA Sustainability Coordinator).

Furthermore, the large amount of stakeholders involved in BSF consultations restricted close communication between the Sustainable City Team and the School community. Consultation meetings often involved representatives from the School community; representatives from the Local Authority's different departments such as transport, urban design, planning, highways and environment, as well as Local Authority advisors. Thus, the task of involving these multiple stakeholders in meaningful discussion about sustainability was difficult. In addition, the sustainability expertise of some parts of the Local Authority was not successfully integrated when writing the sustainability requirement. The Local Authority's Energy Management Unit as well as the Planning Department had a significantly limited involvement during the consultation period and subsequent stages. The Energy Management Unit, responsible for reducing the energy consumption and carbon emission of the Council's properties, was not involved during the visioning process, or in preparing the sustainability requirement. The Unit also had no involvement with bidders during the early bidding stages. The Energy Management Officer felt there was a general lack of internal consultation and communication between the Core Team and other parts of the Local Authority during the writing of the requirement. This, according to the Energy Management Officer was largely due to the personalities involved within the Core Team and their lack of interest in carbon reduction issues at the time. The Planning Department also had a limited role to play during the development of the Authority's sustainability requirement and subsequent design development phases. This was mainly due to the fact that Bristol's local planning policies at the time did not require any set targets for carbon reduction or on-site renewable energy generation. Therefore, the planners' only concern at the time was conforming to current Part L Building Regulation.

Ultimately, the Sustainability Criteria included in the Output Specification were developed by the Technical and Design Advisors in collaboration with the Sustainable City Team and Core Team. The team experienced some difficulties in the drafting of the sustainability requirement within the Output Specification. This was due to the newness of the programme for Bristol as a 'Wave 1' Local Authority, and the lack of experience and knowledge about the implementation of sustainability within the BSF context. The Output Specification followed the standard documentation format provided by PfS. It was fundamentally a large set of documents outlining the Local Authority's BSF strategic objectives, facilities requirements, services specification, performance requirements and availability criteria. It also included annexes outlining statutory requirements in terms of statutory codes, standards, regulations, Local Authority's policy requirements, and design and construction information such as site-specific restrictions among others. The Output Specification also included a document outlining school-specific requirements in terms of strategy, vision and design considerations, and accommodation requirements. Concept design drawings (RIBA Stage B) were also prepared by the Technical Advisors to demonstrate the feasibility of the schemes within the budget and site's constraints.

The principal sustainability objective in the Output Specification was that projects should strive to achieve BREEAM for Schools' 'Very Good' rating for new-build and refurbishment projects. Bristol also stated in their requirement that consideration should be given in the bid to address all applicable issues raised in the 'Sustainable Development Profile' in accordance with the Bristol Sustainable Development Guide for Construction. The Guide requires an applicant for planning permission to consider reducing overall energy use, minimise waste, conserve water, minimise polluting emissions, and maximise use of sustainable materials. The requirements also outlined the Local Authority's higher-level sustainability targets such as the target to reduce the Council's energy consumption, costs, and consequent carbon dioxide emissions by not less than 15% of the 1996/7 figures by the year 2010. Another target related to energy was to purchase 15% of the Council's energy from renewable sources by the year 2010. It should be noted that at the time the requirement was developed, Bristol's local planning policies did not require any site-specific targets for carbon reduction or on-site renewable energy generation. Therefore, BSF schools were not required to meet any set carbon reduction targets at the time. The Local Authority was also required to indicate in the Output Specification how the different requirements would be weighted in bid evaluation. 'Design Quality', which encompasses sustainability, was weighted 10% in the bid evaluation criteria.

2. Clarity of the Sustainable Energy Requirement

The Invitation To Continue Dialogue (ITCD), accompanying Output Specifications and contract documents were sent to the three shortlisted Bidders in January 2005. The Local Authority's commitment to sustainability was acknowledged by the ProjectCo actors, unanimously agreeing that the pursuit of sustainability was clearly stated as an objective in Bristol's Requirement documents. However, one main issue was highlighted regarding the clarity of the sustainable energy requirement, and that is the limited specificity of the sustainable energy requirement in the Output Specification. As shown in Box E1.1.1, ProjectCo actors, particularly the Bid Manager, Project Architect (1) (2) and M&E Engineers (1) (2), raised concerns that limited specificity of the sustainable energy requirement in the Output Specification has left sustainability open to interpretation and somewhat compromised. Following PfS guidance, the requirement was output-based to allow consortia the flexibility to suggest an innovative solution to the Authority's requirement. However, the lack of specific sustainability solutions in the Output Specification had put pressure on the team during the competitive design process. According to the ProjectCo Bid Manager, the flexibility provided to the bidding consortia by the Local Authority has left sustainability 'open to interpretation'. Also, Local Authority representatives, although evidently committed to sustainability, were seen by ProjectCo actors as 'very broad concept people' and 'not organised enough to articulate their requirement'. The Local Authority's provision of non-specific requirement such as the general requirement to 'reduce energy consumption' left room for uncertainty and the team found it difficult to translate the Local Authority's broad higher-level sustainability objectives into actual physical solutions to be incorporated into the building. As the ProjectCo Bid Manager puts it:

> If you can imagine the Authority has a whole set of organised people looking at sustainability, you have our organisation that comes in, and then you have the builders effectively delivering this. To be able to engage at the right levels to say how can you incorporate those types of initiatives and feelings into the issues over

> here *(referring to the builders)*, is quite complex, because these guys *(referring to the builders)* are working under a requirement. It is this translation of what sustainability really is and how people are reading it at different levels and they read the parts of interest to them (ProjectCo Bid Manager).

Indeed, as the design process was running concurrently with bidding, the ProjectCo Bid Manager, as well as Project Architects (1) (2), feared that suggesting high-cost sustainable technologies may result in the ProjectCo losing the bid. Therefore, according to the Project Architect (1), constant efforts were needed to attempt to balance sustainability with the project's financial constraints, leading to sustainability being somewhat 'compromised'.

3. Clarity of the Governing Framework

On BEC, ProjectCo actors agreed that the governing framework, in terms of regulation, standards, and bid evaluation criteria, was made clear in the Output Specification. However, two key issues were highlighted by ProjectCo actors as constraints to achieving an innovative sustainable energy outcome in relation to the governing framework. First, as shown in Box E1.1.2, the Design Team, particularly Project Architects (1) (2) and M&E Engineer (1), highlighted the deficiency of BREEAM as a requirement to deliver low-energy buildings. While the project was designed to a 'Very good' BREEAM rating, the M&E Engineer (1) pointed out that BREEAM may not be particularly effective in promoting energy-conscious design solutions. This was explained by the fact that BREEAM credits could be achieved for issues unrelated to the building such as engaging in consultation with a wide range of stakeholders at the right time. Therefore, no matter how high a project scored, that would not necessarily indicate low carbon emissions or carbon-neutrality.

Second, as shown in Box E1.1.2, the weighting of sustainability in the bid evaluation criteria was seen to dampen ProjectCo actors' incentive to pursue SEI. This was particularly the perception of the ProjectCo Bid Manager, Project Architects (1) (2), and M&E Engineer (1). The weighting of 'Design Quality' being 10% was seen to be significantly low compared to the weighting of other non-building related issues. In fact the 'LEP Services' category was scored higher than 'Design Quality' in bid evaluation, with its forming 40% of the final score. As the ProjectCo Bid Manager argued, the low weighting of design when evaluating bids could have resulted in bidders winning the contract with low-quality-designed schools. The ProjectCo Bid Manager also argued that, in order to encourage sustainability innovation, there has to be a reward for it in bid evaluation. As he said:

> It depends really on 'Can you win a job on sustainability?'– well No! … Because it is not scored high enough. So if the weighted scoring of sustainability was 80% … then you will get more from me (ProjectCo Bid Manager).

That said, although sustainability was not highly weighted in bid evaluation, ProjectCo actors, particularly the Bid Manager and Project Architects (1) (2), saw the pursuit of a sustainable design as an opportunity to differentiate their bid and a strategy to win the contract. According to ProjectCo Bid Manager:

> Sustainability was seen as an important sales factor in securing projects (ProjectCo Bid Manager).

In conclusion, Proposition 1 is not supported in this case study project. Limited specificity and weak definition of the sustainable energy requirement was seen to have left sustainability open to interpretation and somewhat compromised. Local Authority representatives were also seen as 'broad concept people' and unable to articulate their requirement. The ProjectCo actors found it difficult to translate the Local Authority's higher-level sustainability targets into actual physical solutions to be incorporated into the building. In addition, the BREEAM requirement was seen to offer limited incentive to deliver exceptional results for energy efficiency. The low weighting of sustainability in bid evaluation also dampened incentives to pursue an innovative sustainable outcome.

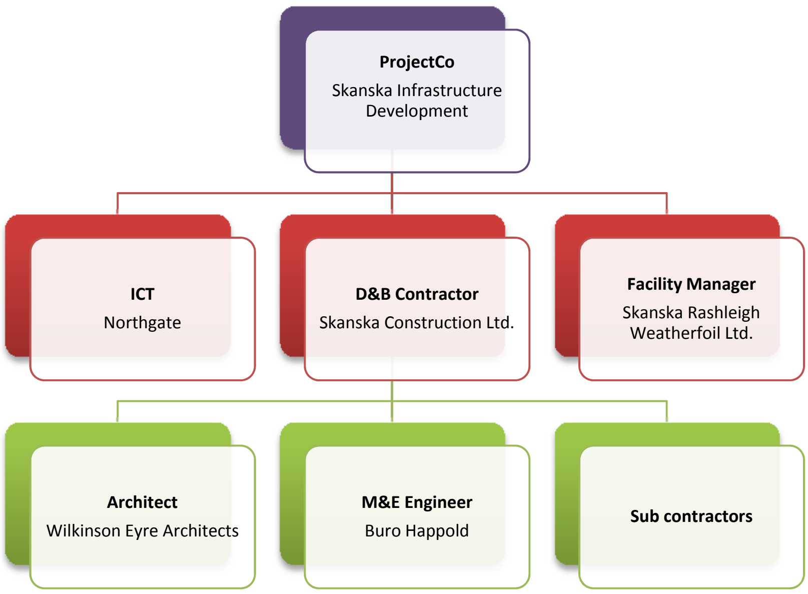
6.3.2 Proposition 2: Findings

The study's second proposition advances that SEI is supported by open communication and effective collaboration within the integrated ProjectCo, particularly among design, construction, and operation disciplines. This section will discuss the extent to which this conceptual proposition translated into experienced reality in supporting the implementation of SEI during the design development stages of BEC. The case study findings will be discussed under two headings: (1) Openness of communication (Box E1.2.1); and (2) Effectiveness of collaboration (Box E1.2.2).

1. Openness of Communication

During the competitive bidding process, bidders coordinated and managed their Consortium. In this case, Skanska Infrastructure Development, the bidder (referred to as the ProjectCo in the remainder of this Chapter) employed, coordinated, and managed Skanska Construction as the D&B Contractor. They also employed, coordinated, and managed the Facility Management Company, Skanska Rashleigh Weatherfoil Ltd, and the ICT provider, Northgate. The Building Contractor, Skanska Construction, then appointed, coordinated, and managed the Architects, Wilkinson Eyre and the M&E Engineer, Buro Happold. They also managed other consultants and members of the supply chain. The Consortium was led by a Bid Management Team which coordinated the Consortium and acted as their interface with public sector clients. Figure 6.2 illustrates the ProjectCo main contractual relationships.

Figure 6.2: The ProjectCo Main Contractual Relationships



Source: Developed for this research study

Open communication among design and construction disciplines, as shown in Box E1.2.1, was supported by the Building Contractor appointing the Design Team at the pre-qualification stage. This was seen by Project Architects (1) (2) to ensure that constructability and environmental performance issues were discussed jointly as early as possible during the design development process. The Facility

Manager, on the other hand, was part of the Skanska Group of companies. While the Design Team and supply chain worked for the Building Contractor, the Facility Manager worked for the ProjectCo; hence, they were one step removed from the Design Team. The facility management team had limited degree of participation during the bidding phase and their contribution had been largely around maintenance issues. Their limited participation in the bidding phase was explained by the FM General Manager to be due to the limited time and resources available at this stage of the project. As the ProjectCo was working at risk, they were reluctant to commit large resources for this stage of the project. This meant that the Facility Management Team was not involved in the choice of technologies implemented in the building, such as the Biomass Boiler, as the decision to implement the technology had been taken during the bidding phase. The FM General Manager was particularly frustrated in the choice of the 'hood bin' system, as opposed to a 'subterranean' biomass storage system, implemented in the School. The choice of the 'hood bin' system meant that a considerable amount of time would be spent on the delivery of the wood chip, which highly complicated the process and affected the price of biomass delivered to the School.

2. Effectiveness of Collaboration

Effective collaboration, as shown in Box E1.2.2, was supported by the collaborative and trustful relationship between the Design Team and the Building Contractor. For the Building Contractor's Design Manager, selecting the most suitable Architect to partner with was crucial to the success of the project. It also highly depended on the sustainability solution sought on the Output Specification. As the ProjectCo Bid Manager similarly argued:

> If we are an organisation and we are employing an Architect for instance and he was a very much a sustainability driver, you probably get that benefit through his designs. But if I wasn't buying that I would probably say 'Do I want that man? Do I want that type of thing?' (ProjectCo Bid Manager).

On the other hand, the Design Team, particularly the Project Architects (1) (2) and M&E Engineer (1), felt the team was working under an 'awkward' position because their ability to pursue sustainability and design innovation highly depended on the Local Authority's and Contractor's preference. Occasionally, there was some conflict of interest between the Architect's desire to produce a 'statement' building and the limited budget available to the Building Contractor. The 'Output Specification' was seen to provide designers with the flexibility to innovate, provided that

Contractors allowed them to do so. The Building Contractor was seen to particularly support 'cost-saving' innovations; otherwise the objective would be limited to meeting the baseline requirements of life cycle cost, energy consumption, and BREEAM. Indeed, designers were seen to be 'fairly restricted' on BSF.

In addition, relationship between construction and operation was seen by the ProjectCo Bid Director, Building's Contractor Design Manager, and FM General Manager, to be supported by the fact that both companies were part of Skanska PLC. This presented adequate incentive for the team to develop a design that was as energy efficient as possible. According to the ProjectCo Bid Manager, the long-term commitment of Skanska through the facility management contract motivated the team to improve the energy-efficient design of the School, because they would be responsible for the School's energy consumption during operation. Skanska's ability to provide an integrated service of design, building and operation was also an incentive for the team to achieve the best energy-efficient design solution, not only to reduce the School's running costs to the company but ultimately to help the company win additional business by being seen to offer a complete green package.

In conclusion, Proposition 2 is not supported in this case study project. Open communication was constrained by the fact that the Facility Manager worked for the ProjectCo, so they were one step removed from the Design Team. Facility management team had a limited degree of participation during the bidding phase due to the limited resources allocated for this phase of the project. Collaborative relationships were restricted by misalignment of objectives among the Architect and Building Contractor. Conflict of interest occasionally occurred between the Architect's desire to produce a 'statement' building and the limited budget available to the Building Contractor. However, relationship between construction and operation was supported by the fact that both companies were part of Skanska PLC, thus incentivising the team to deliver a design that not only met the client's requirement, but also was as energy-efficient as possible during operation.

6.3.3 Proposition 3: Findings

The study's third proposition advances that SEI is supported by open communication and effective collaboration during BSF Local Authority-ProjectCo engagement processes. This section will discuss the extent to which this conceptual proposition translated into experienced reality in supporting the implementation of SEI during the design development stages of BEC. The case study findings will be discussed under two headings: (1) 0penness of communication (Box E1.3.1); and (2) Effectiveness of collaboration (Box E1.3.2).

1. Openness of Communication

Communication between the ProjectCo and the Local Authority was facilitated by single points of contact managing this interface in the form of the Local Authority's Core Team and the ProjectCo Bid Management Team. These single points of contact were seen by both ProjectCo and Local Authority actors to be useful in facilitating clear information flow. However, as shown in Box E1.3.1, communication between the ProjectCo and the different parts of the Local Authority was seen to be restricted by the nature of BSF engagement process. The Engagement Process was seen to be 'difficult', 'exhausting', 'time-consuming' and very 'restricted'. Communication with Bidders was organised in large forums with many stakeholders involved from the Local Authority's side. This restricted the opportunity to develop close relationships. ProjectCo members found it difficult to determine who was doing what within the Local Authority whilst bidding, which restricted communication and collaboration. As there were three Bidders involved, communication was tightly managed by the Core Team to ensure equal treatment, non-discrimination, and transparency. A wide array of issues also needed to be discussed during these meetings and design was only one element of it. Sustainability was not particularly high on the discussion agenda.

However, in order to support the introduction of sustainability into BSF, the Core Team enlisted the help of the Council's in-house Sustainable City Team, responsible for coordinating and promoting sustainability initiatives across the Council and wider community. The Sustainable City Team was invited to take an active role in the BSF programme from its initial consultation stages and was heavily involved with ProjectCo actors throughout. The Sustainable City Team advised the Core Team on sustainability issues and ensured that Bristol's environmental policies were supported throughout the BSF process. ProjectCo actors agreed that the communication with the Sustainable City Team, although restricted, clarified the Local Authority's commitment to sustainability and CO_2 reduction, and thus provided ProjectCo actors with the confidence that their innovative efforts would be appreciated and rewarded in bid evaluation. The high cost and risk involved in BSF PFI bids, the multiple requirements involved, and the low weighting of sustainability in BSF bid evaluation criteria necessitated sufficient communication between ProjectCo and Local Authority's actors to clarify the Local Authority's commitment to the issue. This communication allowed the Output Specification to be translated into an innovative sustainable design.

While the Sustainable City Team was actively involved with bidders, however, the Core Team was unsuccessful in involving the Council's Energy Management Unit in discussion with ProjectCo actors. The reason for this was perceived by the LA Energy Management Officer to be due to the lack of interest in energy issues within the Core Team at the time. Communication between ProjectCo actors and the Energy Management Unit was ineffective throughout the process. The Energy Management Officer was particularly frustrated in the choice of the Bin System, as opposed to a 'subterranean' storage system, as a storage mechanism for the Biomass Boiler implemented in the School. The subterranean system is seen by the Energy Management Officer to be far more superior to the hood bin system because it is easier to load the wood chip with a simple tip, compared to a complicated delivery system with the hood bin. The hood bin system requires a considerable amount of time in the delivery process, which highly affected the price of biomass delivered to the School. The LA Energy Management Officer argued that with effective involvement of his team early on during the process, this problem could have been prevented. As he commented:

> Well, if they perhaps had listened to us earlier on *[referring to ProjectCo actors]*, because we had experience of putting in Biomass Boilers way before them then I think they would have saved themselves some money because now I imagine they're paying a higher price for wood chip than they would be, because of the difficult delivery. So it will be costing more money I think ... I suppose at the end of the day that's not our problem. It's not the Council's problem, because we're not paying for their energy, they are. As long as they're not passing it onto us (LA Energy Management Officer).

2. Effectiveness of Collaboration

Bristol City Council's commitment to sustainability and energy-efficient design was not disputed by the ProjectCo actors. According to the ProjectCo Bid Manager, the Local Authority made a clear commitment to sustainability. However, as shown in Box E1.3.1, ProjectCo actors expressed concerns regarding the ability of the Local Authority to encourage innovation. First, the ProjectCo Bid Manager argued that the competitive dialogue process started with a great deal of ideas and innovations discussed. Later, new ideas tended to dry out as the process progressed with all the solutions becoming similar. He argued that Local Authority representatives tended to 'level out' bids, resulting in bids becoming 'similar'. This highly affected the ability to suggest new ideas. The Local Authority also tended to 'play one bid against the other', which had put ProjectCo actors under extreme pressure whilst bidding and made it more difficult to win the bid. The competitive nature of the design process also meant a synthesis was needed between aesthetical design considerations and the energy efficiency of the building. According to the Project Architect (2), In order to win the competition the building needed to be an attractive building. Subsequently, issues of budget and affordability come into the equation and the design concept had to be a strong concept not to get watered down later.

The second concern highlighted by the ProjectCo actors was the lack of adequate appreciation of affordability within the Local Authority, particularly the Sustainable City Team. The team was seen to be pushing sustainability without being able to understand budgetary constraints. This was mostly felt when trying to incorporate renewable energy technologies into the project. Several discussions took place between the Sustainable City Team and the Building Contractor regarding the implementation of PVs. The Sustainable City Team struggled to convince the Contractor that incorporating PVs was an effective energy efficiency solution, given the ProjectCo's 26-year involvement in running the building. However, the high cost and long payback period associated with PVs rendered the technology an unattractive investment to the ProjectCo's financiers. This was largely disappointing to the Sustainable City Team and the issue resulted in extensive debates. As shown in Box E1.3.1, ProjectCo actors felt that there was a general lack of appreciation of the Contractor's commercial issues in trying to develop a bid that was both viable, so that the scheme would be accepted, as well as profitable as a business. On the other hand, Local Authority actors felt their objectives were misaligned with the objectives of the 'profit-seeking' contractors. Both the ProjectCo Bid Director and LA Technical/Design Advisor highlighted the need for those articulating sustainability to understand budgetary constraints rather than pushing for unattainable requirements and specifications when they said:

> I think what happens is that you need to articulate the sustainability concept better into the actual building solutions or what you end up doing is telling people to do something and then they do what they think is the best answer within the financial constraints, and there is always a compromise ... and these guys *(referring to the Local Authority representatives)* are always saying 'Surely you can do something more, surely you can do that' and we say 'What? And how?' (ProjectCo Bid Manager).

> I think they *(referring to the Local Authority representatives)* have to recognise that if BSF says that the City of Bristol has x million pounds, you can't ask for something

> that you know will cost x+1 and I think that degree of recognition is probably absent at times (LA Technical/ Design Advisor).

The third concern highlighted by the ProjectCo actors, particularly Project Architects (1) (2), was the restricted Architect-Local Authority relationship on BSF design development processes due to the Contractor-led D&B contract. The Project Architects (1) (2) highlighted the fact that, with the BSF process, the Design Team was working under the Contractor from an early stage and, therefore, the Design Team was one step removed from the actual clients, i.e. the Local Authority and School. While the Architect was able to meet representatives from the School and Local Authority, there was significantly less opportunity to build a close relationship and rapport than with a conventional client. The time spent with the School and Local Authority representatives was also significantly less than in a conventional project, restricting the opportunity for the design to develop and mature.

In conclusion, Proposition 3 is not supported in this case study project. Local Authority-ProjectCo communication was restricted by the complexity of the BSF engagement process. In fact, sufficient communication was only achieved due to the Core Team overcoming the inherent barriers to communication brought in by the nature of the BSF engagement process and facilitating communication between ProjectCo actors and their sustainability expertise. It was this communication that clarified the sustainability requirement and allowed the Output Specification to be translated into an innovative sustainable design. However, the engagement of some parts of the Local Authority was largely ineffective, particularly the Energy Management Unit. In addition, Local Authority-ProjectCo collaboration was restricted by the competitive nature of BSF engagement processes, misalignment of objectives between the ProjectCo and the Local Authority, and the restricted Architect-Local Authority relationship.

6.3.4 Proposition 4: Findings

The study's fourth proposition advances that SEI is supported by open communication and effective collaboration during BSF School-ProjectCo engagement processes. This section will discuss the extent to which this conceptual proposition translated into experienced reality in supporting the implementation of SEI during the design development stages of BEC. The case study findings will be discussed under two headings: (1) Openness of communication (Box E1.4.1), and (2) Effectiveness of collaboration (Box E1.4.2).

1. Openness of Communication

The three shortlisted bidders were issued with the Invitation to Negotiate (ITN) documentation in January 2005. Bidders were then invited to develop proposals in response to the Output Specification. Bidders' proposals were then tested against these requirements in a series of stages and gateways. The three bidders were also invited to engage in dialogue with the four schools involved in this phase of the BSF programme, including BEC. The engagement process took a period of six months from January to July 2005. The purpose of the engagement process was for Bidders' Design Teams to understand the School's aspirations and requirements. All parties involved in the School—student, management team, teaching and support staff and governors—contributed to the design process. The School was involved in milestone meetings throughout the ITN phase. Engagement meetings were organised by the Core Team and often attended by representatives from the team and their technical advisors. Skanska's engagement team included the Bid Director and representatives from the Building Contractor, Architect, and M&E Engineers. The Architect held design presentations for students in the various age groups and design workshops with staff at different levels.

Effective engagement between the ProjectCo and the School Community was supported by a committed and enthusiastic Principal. The School Principal was a 'strong and charismatic' character and was actively involved throughout the design, construction, and operation of the School. According to the Project Architect (2), a good Head Teacher is important for effective engagement with the School. However, as shown in Box E1.4.1, several issues were raised by ProjectCo actors regarding the effectiveness of their engagement with the School. The limited time allocated for the engagement process was seen to complicate the process. Meetings with the School community were tightly spaced with a large amount of work to be done in between. Communication between the ProjectCo and the School during the competitive dialogue stage was seen by ProjectCo actors to be 'formal' and 'rigid'. Engagement meetings were 'orchestrated' by the Core Team, and the School's ability to discuss the design freely with bidders was limited by the competitive nature of the process. The School had to engage in dialogue with three bidders simultaneously. Therefore, the School had to be disciplined and communicate straightforward facts. The School was also discouraged from getting into sensitive dialogue and from openly favouring any particular bidder. The engagement process was managed by the Core Team to ensure that the School was keeping within their agreed requirement and that the messages they sent to bidders were uniform. As the ProjectCo Bid Manager puts it, schools were 'policed' during their engagement with bidding consortia.

The competitive nature of the design process was also seen to complicate this engagement. Due to the newness of the process, there was a great deal of sensitivity regarding commercial knowledge and the School was required to sign several documentations about confidentiality. On the other hand, the ProjectCo Bid Manager argued that the School reaped the benefit of the competitive nature of the ITN stage by combining ideas from different bids and, therefore, achieving the best design possible. The School community tended to transfer the best design ideas from one bid to the other through the engagement process. While this was done in a way that did not jeopardise PFI guidance, it put bidders under considerable pressure. Bidding consortia were constantly in a 'playing field' whilst bidding and it was made more difficult for them to win the bid.

However, communication with the School greatly improved after the ProjectCo was appointed as the Preferred Bidder. The Architect had the opportunity to talk directly to the School and the local community, which improved communication and collaboration. Still, this was seen to be too late in the process, as many design decisions were taken by then.

2. Effectiveness of Collaboration

Joint School-ProjectCo collaboration, as shown in Box E1.4.2, was supported by the School's interest in the educational benefits of a sustainable design. The School was seen as a good promoter of sustainability and was particularly interested in its educational benefits and its effect on the wider community. According to the School Principal, while sustainability was not high on the agenda when writing the requirement, it rose rapidly in conversations with bidders. The School took part in evaluating options and deciding on the sustainable solutions implemented on their new-building. However, although committed to sustainability, the School's ability to effectively contribute to the discussion about its delivery was seen to be limited by their lack of technical knowledge about the subject. According to ProjectCo Bid Manager, the School community was aware of the features they wanted to implement on their new-building. However, in terms of the physical delivery of sustainability in its integrity, they had little discernment. The conflict between transformational learning aspiration and energy-conscious design was also seen as an issue of concern. The School's ultimate priorities were the educational requirements and delivering transformational learning environments for its pupils. ProjectCo actors expressed the difficulty of balancing the School's transformational learning aspiration with environmental requirements. The School's aspiration was for uplifting social spaces and generously proportioned sports halls. In order to differentiate themselves from other bidders, the ProjectCo designed large open social spaces for the students to gather and socialise. However, these spaces significantly exceeded the area requirements of BB98 (Briefing Framework for Secondary School Projects). They also increased the building's heating and lighting requirements. According to ProjectCo Bid Manager, there was a dilemma on the way to balance these exciting large spaces, whilst keeping them to expectations in terms of their environmental performance. As the ProjectCo Bid Manager said:

> If you go back and look at countries that are using natural ventilation without mechanical means which are very hot countries, they tend to have very dense buildings, very small amount of windows and they are cool because effectively the buildings never heat up, but they go against what we see in this country as educationally the best way because we want light airy big buildings. So from where education is going I don't think you can ever truly get to the best result because I think they are in conflict in some of the things (ProjectCo Bid Manager).

Moreover, due to the limited budget available, there was occasional conflict between the School's educational requirement and the requirements for sustainability. Schools were sometimes faced with a difficult choice between investing in their educational requirement or improving the sustainability features of their building. As the Bid Manager recalls:

> So if you want to invest £50K on grey water harvesting or you can build in more equipment into a classroom, what will you do? Well you have to decide. Some of the schools said 'Well we want to put in grey water harvesting because actually this is what we need to be doing.' So it is not about them buying new equipment, they want to improve the sustainability of the building and the whole community and that is their contribution to it (ProjectCo Bid Manager).

In addition, the nature of the PFI management contract was seen to reduce the amount of the School's control over their building, particularly in relation to the environmental performance and energy efficiency of the building. According to the School Principal, as a PFI School the building's energy performance is the responsibility of the ProjectCo and service provider, thus beyond his direct control. This was seen to reduce their interest in considering the energy performance of their building as a priority.

In conclusion, Proposition 4 is not supported in this case study project. School-ProjectCo communication was somewhat constrained by the formal, restricted, and competitive nature of the engagement process. The Design Team was working under the Building Contractor and thus one step removed from the School. School-ProjectCo collaboration towards sustainability was constrained by the School's lack of technical knowledge about the subject. The Design Team also needed to manage the conflict between the School's transformational learning aspiration and energy-conscious design. There was occasional conflict between the School's educational requirement and the sustainability requirement due to the limited BSF budget. The BSF PFI contract was also seen to reduce the School's control over the energy performance of their building, limiting their incentive to consider the energy performance of the building as a priority.

6.3.5 Proposition 5: Findings

The study's fifth proposition advances that SEI is supported by clear, appropriate, and manageable allocation of the risks associated with the project's energy performance. This section will examine the extent to which this conceptual proposition translated into experienced reality in supporting the implementation of SEI during the design development stages of BEC. The case study findings will be discussed under three headings: (1) Clarity of risk allocation (Box E1.5.1); (2) Appropriateness of risk allocation (Box E1.5.2); and; (3) Manageability of risk allocation (Box E1.5.3).

1. Clarity of Risk Allocation

The energy strategy adopted on BEC was largely driven by the allocation of several energy-related risks to ProjectCo actors. Particularly important to ProjectCo actors were: *availability risk* and *energy consumption risk*. The availability risk, as it relates to the building environment, is that associated with the building environment not meeting agreed criteria and thus incurring availability penalties. As part of the PFI contract an 'Availability Clause' is linked to the Payment Mechanism in which a fine is levied for unavailability of any teaching spaces that exceed 28°C for more than 120 hr/yr (based on BB 101—Ventilation of School Buildings). *Energy consumption risk is* that associated with the building's operational energy consumption exceeding agreed standards for maximum annual energy consumption in the contract. These two types of risk were seen as the major drivers for the innovative ventilation chimney design. The energy strategy was also influenced by other risks such as the *BREEAM target risk*, the risk that the building fails to achieve the BREEAM 'Very good' target and hence incurring penalties; *technical risk*, the risk that the solution adopted fails to meet technical criteria; and *capital cost risk*, the risk that the solution adopted is too expensive and hence rejected by the client.

As shown in Box E1.5.1, ProjectCo actors unanimously agreed that risk allocation associated with the project's energy performance was made clear and is considered acceptable. The way the BSF contract was constructed made it clear how the risks associated with the Project's energy performance were managed.

2. Appropriateness of Risk Allocation

As shown in Box E1.5.2, ProjectCo actors unanimously agreed that risk allocation associated with the project's energy performance was considered appropriate. Contractually, meeting the Availability Clause was the responsibility of the ProjectCo SPV as part of the BSF PFI contract. Within the ProjectCo, the Building Contractor was responsible for the design and construction of the building, meeting the energy targets for the initial period. The Facility Manger assumes both energy consumption and energy tariff risk for the first three years. Following this, energy consumption becomes the responsibility of the Facility Manager, while the Local Authority retains the risk on tariff.

3. Manageability of Risk Allocation

As shown in Box E1.5.3, manageability of the risks allocated to ProjectCo actors was an important criterion when implementing SEI. While the allocation of energy-related risks to ProjectCo actors was considered manageable and, in fact, drove SEI, the perception of excessive innovation-related risks shaped the type of SEI implemented. The SEI implemented on BEC was largely a strategy to manage several energy-related risks allocated to ProjectCo actors. Particularly, availability risk was identified and evaluated at the beginning of the design process and the financial penalties associated with not meeting the 'Availability Clause' were deemed significant enough to influence the design process. The ProjectCo SPV in agreement with the Building Contractor decided to pursue an extremely robust and safe design solution by setting challenging environmental targets for the Design Team to meet. Therefore, instead of pursuing a strategy where teaching spaces are designed to reach 28°C for no more than the maximum acceptable limit of 120 hr/yr, the target was set to the lower figure of 20 hr/yr. This was an extremely ambitious target at the time and was pushing the boundaries of what could be achieved for sustainability. To develop the energy strategy, the Design Team needed to meet the availability criteria, whilst managing energy consumption risk by maintaining agreed standards for maximum annual energy consumption on the PFI contract. Achieving the balance between these two conflicting requirements meant that the installation of mechanical ventilation and HVAC systems was to be minimised as much as possible whilst optimising passive design principals. The Design Team, therefore, developed a design strategy in which natural ventilation is maximised across the building by developing ventilation chimneys in all teaching spaces. Openable windows draw in fresh air that rises through the chimneys and leaves via louvers on the roof. The innovative chimney design contributed to meeting the 'Availability Clause' by offering optimal air flow for cross-ventilation in teaching spaces. It also reduced the need for mechanical ventilation by maximising natural ventilation, thus reducing energy consumption.

Indeed, the innovative chimney design was developed as a direct result of the risk-averse attitude of the ProjectCo and their desire to protect their investment in the long-term. Pursuing this strategy involved higher costs to the Design Team in terms of design development time and the purchasing and production of components by suppliers. However, it was justified by the reduced risk and increased certainty that the building would meet the agreed criteria and safeguard the ProjectCo and financiers' investment in the long-term. Inevitably, pursuing the innovative chimney design entailed a certain amount of technical risk associated with the technology not performing as expected. This risk was managed by undertaking numerous prototyping and simulation tests. The Architect and M&E engineers had a long history of collaborating on previous projects and worked closely to develop the design. The extensive experience of the M&E engineers and their long track record of innovation provided further assurance to the team. An important requirement by the investors was that the chimney design should not be 'too experimental' to safeguard their investment and long-term commitment to the project. According to Project Architect (1) innovation was stifled by the need for 'reliability', which was an important criterion when selecting solutions to be adopted in the building. Therefore, the chimney design was predominantly a new combination of tried and tested technologies. As the Project Architect (1) argued, the team was largely 'following best practice rather than innovating'. The implementation of high-cost technologies with extended payback periods, such as PVs was also avoided to reduce capital cost risk.

In conclusion, Proposition 5 is supported in this case study project. The risks associated with the project's energy performance were generally considered clear, appropriate, and manageable. Indeed, the SEI implemented was developed in order to manage several risks allocated to the ProjectCo and safeguard its long-term commitment to the project, particularly the conflicting availability and energy consumption risks. However, the multiple case study findings also indicated that excessive perceived risks shaped the type of SEI implemented. Perceived technical risks led to the development of a design that was predominantly a new combination of tried and tested technologies. Perceived capital cost risk also inhibited the adoption of high-cost technologies with long payback periods.

6.3.6 Proposition 6: Findings

The study's sixth proposition advances that SEI is supported by incentive-based payments linked to the project's energy performance. This section will examine the extent to which this conceptual proposition translated into experienced reality in supporting the implementation of SEI during the design development stages of BEC. The case study findings are shown in Box E1.6.1.

Bristol City Council adopted the standard BSF contract and Payment Mechanism in their contract with the ProjectCo. Energy efficiency is part of the efficiency in the FM service contract and is part of the unitary charge for the PFI contract. In terms of energy, the standard BSF Payment Mechanism dictates that the Facility Manager operating the School takes the risk on both energy consumption and tariff for the first three years. During this period the energy performance of the building is monitored by the Facility Manager. At the end of this period, energy consumption is benchmarked and the Facility Manager subsequently takes the risk on consumption while the Local Authority takes the risk on tariff. This re-benchmarking procedure is scheduled to take place every three years. The ProjectCo compares its prices for energy to the price of equivalent service provision in the market. Subsequently, the corresponding part of the Unitary Payment is adjusted according to a pre-agreed formula. The ProjectCo can reap the benefit of any cost savings as a result of introducing energy-saving systems and strategies within the utility period before energy consumption is re-benchmarked.

ProjectCo actors, as shown in Box E1.6.1, unanimously highlighted the deficiency of the standard Payment Mechanism in providing ProjectCo actors with incentive for continuous improvement in energy efficiency or installation of low-carbon technologies. This was because the continuous re-benchmarking of energy consumption resulted in the ProjectCo hardly reaping any financial benefits from doing so. The limited period from which the ProjectCo can benefit from introducing innovative energy-saving technologies before energy consumption is re-benchmarked offers limited incentive for ProjectCo actors to invest in high-cost renewable energy technologies to reduce energy consumption. While the ProjectCo is incentivised to avoid penalties for non-compliance, there is no incentive in the Payment Mechanism for ProjectCo actors to innovate to help improve the energy performance of the building mid-contract.

In conclusion, Proposition 6 is not supported in this case study project. The continuous benchmarking of energy consumption every three years offers the ProjectCo limited incentive to introduce innovative sustainable and energy-efficient technologies mid-contract because they will reap limited benefits from doing so.

6.4 Summary

The aim of this research study is to develop an understanding of the capacity of the PFI project delivery model to support the implementation of SEI on BSF new-build school buildings. This Chapter discussed the extent to which six conceptual propositions have translated into experienced reality in supporting the implementation of SEI during the design development stages of BEC. The main case study findings are as follows:

1. Proposition 1 was not supported. Lack of specificity and weak definition of the sustainable energy requirement was seen to have left sustainability open to interpretation and somewhat compromised. Local Authority representatives were seen as ‘broad concept people’ and unable to articulate their requirement. The ProjectCo actors found it difficult to translate the Local Authority’s higher-level sustainability objectives into actual physical solutions to be incorporated into the building. In addition, the BREEAM requirement was seen to offer limited incentive to deliver exceptional results for energy efficiency. The low weighting of sustainability in bid evaluation dampened incentives to pursue an innovative sustainable outcome.

2. Proposition 2 was not supported. Effective communication was constrained by the fact that Facility Management worked for the ProjectCo, so they were one step removed from the Design Team. The Facility Management team had a limited degree of participation during the bidding phase due to the limited resources allocated to this phase of the project. In addition, some conflict of interest occasionally occurred between the Architect’s desire to produce a ‘statement’ building and the limited budget available to the Building Contractor. However, relationship between construction and

operation was supported by the fact that both companies are part of Skanska PLC, thus incentivising the team to deliver a design that not only met the client's requirement, but also as energy-efficient as possible during operation.

3. Proposition 3 was not supported. Local Authority-ProjectCo communication was restricted by the complexity of the BSF engagement process. In fact, sufficient communication was only achieved due to the Core Team overcoming the inherent barriers to communication brought in by the nature of the BSF engagement process and facilitating communication between ProjectCo actors and their sustainability expertise. It was this communication that clarified the sustainability requirement and allowed the Output Specification to be translated into an innovative sustainable design. However, the engagement of some parts of the Local Authority was largely ineffective, particularly the Energy Management Unit. In addition, effective Local Authority-ProjectCo collaboration was restricted at times by the misalignment of objectives between the ProjectCo and the Local Authority, the restricted Architect-Local Authority relationship, and the competitive nature of BSF engagement processes.

4. Proposition 4 was not supported. School-ProjectCo Communication was somewhat restricted by the formal, constrained, and competitive nature of the engagement process. The Design Team was working under the Building Contractor and thus one step removed from the School. School-ProjectCo Collaboration was constrained by the School's lack of technical knowledge about sustainability. The Design Team also needed to manage the conflict between the School's transformational learning aspiration and energy-conscious design. There was occasional conflict between the School's educational requirement and the sustainability requirement due to the limited BSF budget. The BSF PFI contract was also seen to reduce the School's control over the energy performance of their building, thus limiting their incentive to consider the energy performance of their building as a priority.

5. Proposition 5 was supported. The risks associated with the energy strategy were generally considered clear, appropriate, and manageable. The SEI implemented was developed in order to manage several risks allocated to the ProjectCo and safeguard its long-term commitment to the project, particularly the conflicting availability and energy consumption risks. However, the multiple case study findings also indicated that excessive perceived risks shaped the SEI implemented. Perceived technical risks led to

the development of a design that was predominantly a new combination of tried and tested technologies. Perceived capital cost risk also inhibited the adoption of high-cost technologies with long payback periods.

6. Proposition 6 was not supported. The continuous benchmarking of energy consumption scheduled to take place every three years offers the ProjectCo limited incentive to introduce high-cost innovative technologies mid-contract because they would reap limited benefits from doing so.

Chapter 7: Case Study 2

Image 7.1: SVC: Aerial View
Courtesy of LCC (2010)

This Chapter presents the findings from Soar Valley College (SVC) case study. The Chapter is divided into four sections. The first section provides a brief introduction to the project, the Sustainable Energy Innovation (SEI) implemented, and the project's sustainable energy design features. The second section outlines the key sources of data. The third section explores the case study findings based on the six propositions developed in Chapter 4. The fourth section offers a concluding summary of the case study's findings.

7.1 Introduction

SVC is one of four schools[4] in the first phase of Leicester City Council's £235m BSF programme. It is a large £21.5m mainstream secondary school for 1275 pupils aged 11–16. The catchment area is demographically broad, with children from many different backgrounds and cultures.

Image 7.2: SVC: Outdoor Area
Courtesy of LMEC (2009)

The new SVC development was part of Leicester's 'Sample' schemes; it therefore was one of four school projects the Council went to market with when procuring their BSF programme and was designed as part of a competitive dialogue process. Leicester City Council's OJEU notice was published in May 2005 and a Preferred Bidder was selected in September 2006. The Council's Preferred Bidder, Miller, was a Consortium comprising Miller/GSI/NIBC (Equity Providers), Miller Construction (Building Contractor), Architects Design Partnership (Architect), Gifford (M&E), G4S (Facilities Management) and Northgate Information Solutions (ICT). Financial Close was reached in December 2007 creating Leicester Miller Education Company (LMEC). Construction on site started in August 2007 under an Advanced Work Agreement and the school was opened in June 2009.

SVC was selected as a case study as it displayed no evidence of any implemented SEI. While the school achieved 'Excellent' BREEAM rating and 35% reduction in CO_2 Emission (compared to Part L 2002 requirements), the school's energy strategy was conformance-based and depended on the installation of a conventional Biomass Boiler. Figure 7.1 outlines SVC sustainable energy design features.

[4] The other three schools are: Beaumont Leys School, Fullhurst Community College, and Judgemeadow Community College.

Figure 7.1: SVC Sustainable Energy Design Features

Energy Efficiency:

The new school building is designed and built to reduce energy demand relative to Part L 2006 standards through use of passive design features such as:

- **Building Fabric:** An air-leakage rate of $5m^3/m^2/hr$ has been specified beyond building regulation. U-values at 10% better than 2002 building regulations have also been specified. The air-leakage rate and U-values used will minimise the heating demand, and hence heat loss in unoccupied spaces.
- **Lighting:** 2% daylight factor was achieved within most of rooms. Large roof lights were used to light the central atriums and the flexible teaching space area within the teaching wings.
- **Ventilation:** Mix mode ventilation is adopted with a mixture of natural ventilation in the majority of classrooms and mechanical ventilation in some of the larger spaces, such as the dining hall and kitchens. Vertical riser stacks went through the whole building.
- **Heat Recovery:** 65% heat recovery on ventilation systems is specified.

Renewable Energy:

- **Biomass Boiler:** The renewable energy target for 20% was met through the installation of a Biomass Boiler. Electricity is provided off grid.

The School design achieved 35% reduction in Co_2 emission (against Part L 2002 Building Regulation)

Source: Developed for this research study

7.2 Case study Participants

Data collection for this case study involved 13 semi-structured interviews with key project stakeholders. Table 7.1 lists the actors that took part in the research study. It describes each interviewee in terms of his/her respective organisational team and the interviewee position within the team (please refer to Table 5.4 in Chapter 5 for a description of how stakeholders were selected to be included in the study, including a description of their role and responsibilities). It also outlines the title used to refer to the interviewee within the case study findings.

Table 7.1: SVC Case Study Participants

Team	Interviewee	Title used to refer to interviewee within the case study findings	Ref.
The Local Authority: Leicester City Council (LCC)			
BSF Management Team	Project Manager	LA BSF Project Manager	L1
Property Services Department	In-house Technical Advisor	LA Technical Advisor	L2
Transforming the Learning Environment (TLE) Team	Sustainability and Low-carbon Building Officer	LA SLC Building Officer	L3
	Sustainability Manager	LA Sustainability Manager	L4
Planning Department	Senior Planning Officer	LA Senior Planning Officer	L5
Environment Team	Senior Officer	LA Senior Environment Officer	L6
The ProjectCo: Miller Consortium			
Bid Management Team	Bid Manager	ProjectCo Bid Manager	P1
Building Contractor (Miller Construction)	Operations Manager	Building Contractor's Operations Manager	P2
Architect (ADP)	Project Director (1)	Project Architect (1)	P3
	Project Director (2)	Project Architect (2)	P4
M&E Engineer (Gifford)	Project Engineer	M&E Engineer	P5
Facility Manager (G4S)	Design Coordinator	FM Design Coordinator	P6
The School: SVC			
School Engagement Team	Business Manager	School Business Manager	S1

Source: Developed for this research study

7.3 Case Study Findings

This section will present findings from SVC case study. The case study findings are divided into six subsections according to the six research propositions developed in Chapter 4. Table E2 in Appendix E reviews the key findings for each proposition. The table summarises emergent issues for each conceptual construct (defined in Table 5.6 of Chapter 5), synthesised from the 13 case study interviews, and demonstrates the theory underlying the empirical findings. Effort was made to tie the Box related to each theoretical construct clearly to the text. Each proposition subsection is also illustrated with quotes from the case study interviewees.

7.3.1 Proposition 1: Findings

The study's first proposition advances that SEI is supported by the greater clarity of the sustainable energy requirement and governing framework on the BSF PFI Output Specification. This section will discuss the extent to which this conceptual proposition translated into experienced reality in supporting the implementation of SEI during the design development stages of SVC. The case study findings will be presented under three headings: (1) The development of the sustainable energy requirement; (2) Clarity of the sustainable energy requirement (Box E2.1.1); and (3) Clarity of the governing framework (Box E2.1.2).

1 The Development of the Sustainable Energy Requirement

Leicester City Council is a BSF 'Wave 1' Local Authority. Leicester City Council's BSF Programme was managed by a Core BSF Project Management Team (referred to as the Core Team in the remainder of this Chapter) which included a Project Director, two project managers, and three administrators. The Core Team worked in close collaboration with the Education Department (Children and Young People Services). The BSF Project Director was a former Head Teacher with considerable knowledge about schools and construction and he acted as the Client Design Advisor. The Authority decided not to appoint external advisors on the development of its BSF documentation and most educational, design, and technical advice was sourced from within the Local Authority when needed.

Image 7.3: SVC: Facade
Courtesy of LCC (2009)

At the time BSF was introduced in 2005, Leicester's schools were faced with many difficulties, including underachievement, disruptive behaviour, and poor building stock. Key concerns involved higher than average rates of poor language skills, turbulence (the constant movement of families in, out, and around the City) and migration from City schools by more able pupils. BSF was seen as an opportunity for the City Council to reverse underachievement in its secondary schools and inspire innovative teaching and management. The BSF programme provided the opportunity to help realise the City Council's vision: to provide personalised education for everybody, supported by the most up-to-date technology and resources, and available to the wider community (LCC, 2005).

Schools delivered under the BSF programme were also influenced by Leicester City Council's sustainability agenda. Indeed, Leicester City Council has played an active role for many years, encouraging and supporting measures that protect the environment. In recognition of this, Leicester became Britain's first Environment City in 1990. Since then, the City Council has adopted a number of green policies and an Environmental Strategy to ensure its strategies and operations meet high sustainability standards. The Council's 25-year vision is to be Britain's 'Most Sustainable City', with Leicester's schools forming part of the City Council's plan to tackle climate change. While the national target for zero-carbon emission was set for 2016, Leicester City Council set the target of 2013 for its new schools to demonstrate its commitment to the lowering of greenhouse emissions. The City Council aspiration was to ensure that schools are exemplary models of sustainable development and are places where children can learn about sustainability issues by experiencing what happens in their own school buildings.

However, the ability of Leicester City Council to develop a clear sustainable energy requirement to reflect these high-level sustainability aspirations was restricted. As Leicester was a BSF 'Wave 1' Local Authority, there were limited examples to advise the team. The whole BSF process was a steep learning curve to the Local Authority, which had no expertise of procuring through the PPP or PFI routes. The initial consultation period leading to the development of the Output Specification was tightly managed by the Core Team. The Director of Education at the time decided not to involve other parts of the Local Authority and work autonomously with the Core Team in developing the Output Specification. The decision not to involve other parts of the Local Authority was largely due to lack of adequate funding and resources to secure this involvement. Due to the newness of the BSF programme, senior management within the Local Authority were struggling to understand how to deliver and fund the BSF programme. The LA Property Services Department, Planning Department, and the Sustainability Manager within the Education Department had minimal involvement during the initial consultation period. The LA Sustainability Manager explained his lack of involvement during the development of the sustainability requirement when he said:

> I think with a lot of these schemes what happens is, you get a massive capital investment, but there's no additional revenue to go along side it. So there's no additional revenue to support the client-side infrastructure that needs to be in place to deliver it. And it takes a while for the Council and members to understand and also find the funding, because there's never surplus funding around to actually fund the client-side. So, I think part of the reason why I was not involved earlier on, is that the Authority were still trying to understand how they were going to actually deliver this, and how they were going to find the funding to deliver it (LA Sustainability Manager).

Eventually, to develop the Local Authority's sustainability requirement, the Core Team enlisted the help of the LA Environmental Team. The Environment Team found it difficult to develop the sustainability requirement within the Output Specification. This was due to the newness of the programme and the lack of understanding of the applicability of sustainability principals within the BSF context. The team was also confused by conflicting government targets, requiring BSF schemes to simultaneously reduce CO_2 emissions, whilst also increasing ICT provision in schools. The final sustainability requirement was principally governed by Leicester's policy on sustainability and carbon reduction target. The requirement involved three key objectives:

- Projects should strive to achieve BREEAM for Schools' 'Excellent' rating for new-build and 'Very Good' for refurbished buildings.
- Projects need to meet Leicester's development planning requirement, which requires new developments to achieve 11% on-site renewable energy generation as a condition for compliant planning application.
- New-build projects should strive to be zero/low carbon.

In addition, the Local Authority was required to indicate in the Output Specification how the different requirements will be weighted in bid evaluation. 'Design Quality', which encompasses sustainability, was weighted 10% in the bid evaluation criteria. Sustainability and energy efficiency issues commanded a relatively small percentage within that weighting. While sustainability was high on the Local Authority's corporate agenda, the large number of issues involved in BSF meant that sustainability was not highly weighted in bid evaluation criteria.

2. Clarity of the Sustainable Energy Requirement

The ITCD, accompanying Output Specifications and contract documents were sent to the three shortlisted bidders in August 2005. ProjectCo actors unanimously agreed that the output-based nature of the Output Specification provided the team with considerable autonomy to pursue innovation. However, one key issue was highlighted by ProjectCo actors as a constraint to the clarity of the sustainable energy requirement and that was its limited achievability. As shown in Box E2.1.1, ProjectCo actors, particularly the Bid Manager, Project Architects (1) (2) and M&E Engineer, raised concerns that Local Authority representatives lacked adequate understanding of their requirement, resulting in its limited achievability. Particularly, the requirement for schools to achieve zero-carbon was considered to be unrealistic at the time, both technically and financially. According to the ProjectCo Bid Manager:

> When writing this requirement, insufficient consideration was given to its impact on the initial funding of sample schemes and the applicability of the approach across the whole BSF portfolio (ProjectCo Bid Manager).

There was a perceived general lack of understanding among Local Authority representatives of the financial and technological limitations of such a requirement. The ProjectCo was ultimately forced to derogate against the requirement on the BSF contract.

3. Clarity of the Governing Framework

On SVC, ProjectCo actors agreed that the governing framework, in terms of regulation, standards, and bid evaluation criteria, was made clear in the Output Specification. The BREEAM 'Excellent' requirement was also seen as the main driver for sustainability on this project. In fact, the Project Architect argued that without the BREEAM requirement being an important part of the contract, affordability pressures on the Contractor may have resulted in the buildings not achieving the target. As the Project Architect (2) commented:

> None of the buildings would have achieved BREEAM Excellent if that criteria hadn't been set as 'You must achieve it and if you don't they'll be financial penalties then!', because otherwise the Contractor would not have committed to achieving it (Project Architect [2]).

However, two key issues were highlighted by ProjectCo actors as constraints to achieving an innovative sustainable energy outcome in relation to the governing framework. First, as shown in Box E2.1.2, the inability of BREEAM to promote energy efficiency was highlighted by ProjectCo actors. While the project achieved 'Excellent' BREEAM scoring, the Project Architect (1) highlighted that this scoring can be achieved by gaining credits in issues unrelated to the building performance, such as having consultations at the right time. Therefore, BREEAM 'Excellent' does not necessarily indicate that the most energy-efficient building was achieved. In fact, on one of the other sample schemes, the Design Team was struggling to introduce natural lighting at the back of a number of classrooms because their design layout was too deep in this particular arrangement. Redesigning these classrooms would have been the best solution, not only to achieve BREEAM credits, but also for the School in the long term. However, due to the limited time allocated to the design process, the classrooms layout was not modified. The BREEAM credits associated with introducing natural lighting to those classrooms was forgone in favour of other credits that were easier to achieve. The Facility Manager also added that BREEAM alters the way contractors think. The Contractor may install PVs or a Wind Turbine in order to gain BREEAM points, where these technologies are inefficient, not needed, and cannot be used. The difference in the BREEAM requirement between new-build and refurbishment projects was also problematic as it resulted in the Contractor developing bespoke specifications for each school, instead of purchasing all materials, fittings, and equipment to the highest standards. In addition, while achieving zero-carbon schools may require linking to District Heating Networks, the Project Architect (2) pointed out that BREEAM does not recognise off-site renewable energy generation.

Second, as shown in Box E2.1.2, the weighting of sustainability in BSF bid evaluation criteria was seen to be significantly low in relation to the weighting of other non-building-related issues. As the ProjectCo Bid Manager puts it:

> It wasn't one of the key elements. No. I mean it's almost a case of as long as we'd achieved the minimum standards and got the tick in the box, then it was a more of a gateway than anything else (ProjectCo Bid Manager).

In fact, the ProjectCo main incentive whilst bidding was to win the contract. Therefore, the team pursued a low-energy design as they felt it would increase the probability of the ProjectCo becoming Preferred Bidder. Apart from this, there were limited financial incentives for the team to achieve exceptional results for sustainability and energy efficiency.

In conclusion, Proposition 1 is not supported in this case study project. While the output-based nature of the requirement offered the team with the flexibility to suggest innovation, it provided limited incentive to do so. The achievability of the requirement was questionable and Local Authority representatives were seen to lack adequate understanding of their requirement. Indeed, the requirement for zero-carbon schools was seen to be unrealistic both technically and financially at the time. In addition, while BREEAM was seen as the main driver for sustainability on this project, BREEAM was seen to be deficient in ensuring an energy-efficient building. The low weighting of sustainability in bid evaluation also offered limited incentive for ProjectCo actors to pursue SEI.

7.3.2 Proposition 2: Findings

The study's second proposition advances that SEI is supported by open communication and effective collaboration within the integrated ProjectCo, particularly among design, construction, and operation disciplines. This section will discuss the extent to which this conceptual proposition translated into experienced reality in supporting the implementation of SEI during the design development stages of SVC. The case study findings will be discussed under two headings: (1) Openness of communication (Box E2.2.1); and (2) Effectiveness of collaboration (Box E2.2.2).

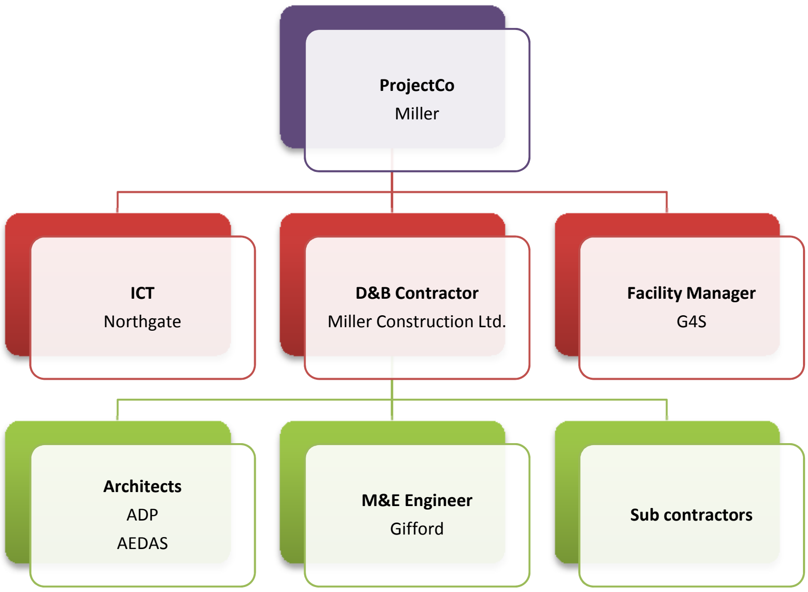
1. Openness of Communication

During the competitive bidding process, bidders coordinated and managed their Consortium. In this case, Miller, the Bidder (referred to as the ProjectCo in the remainder of this Chapter), employed, coordinated and managed Miller Construction as the D&B Contractor. They also coordinated the Facility Management Company, G4S, and the ICT provider Northgate. The Building Contractor, Miller Construction, then appointed, coordinated and managed the Architects (ADP and AEDAS[5]), the M&E

[5] AEDAS designed two of the reference schemes, Judgemeadow and Beaumont Leys and ADP designed the other two, Soar Valley and Fullhurst.

Engineer (Gifford), and other consultants and members of the supply chain. The Consortium was led by a Bid Management Team which coordinated the Consortium and acted as their interface with public sector clients. Figure 7.2 illustrates the ProjectCo main contractual relationships.

Figure 7.2: The ProjectCo Main Contractual Relationships



Source: Developed for this research study

Open communication among design and construction disciplines, as shown in Box E2.2.1, was supported by the Building Contractor appointing the Design Team at an early stage. This was seen by the Project Architects (1) (2) to allow early discussion on constructability, affordability, and project planning. On the other hand, the Facility Management Company, G4S, partnered with Miller during the pre-qualification stage. While the Architect, consultants, and supply chain worked for the Building Contractor, Facility Management worked for the ProjectCo. Thus, they were one step removed from the Design Team. The Facility Management Team had a limited degree of participation during the bidding phase with only one member of the Facility Management Team on the bid team. Their limited participation in the bidding phase was largely explained by the limited time and resources available at this stage of the project. As the team was working at its own risk, the Facility Manager, G4S, was reluctant to commit too many resources into the bid. In addition, their contribution following Financial Close has been largely around maintenance issues and they had limited influence on design development decisions. The limited involvement of the Facility

Management Team during the early design development stages resulted in several disagreements between the Design Team and the Facility Management Team post-Financial Close. New Facility Management personnel joined the team closer to opening the School and requested several design changes to be implemented. These were particularly concerning the Building Management System (BMS) in order to improve their control over the building. However, these changes were difficult to implement at such a late stage in the process.

2. Effectiveness of Collaboration

A 'team approach' was adopted at the outset between ProjectCo actors, and relationships were largely regarded as open and honest. The Architect, M&E, and Building Contractor worked collaboratively from an early stage. However, according to the Project Architect (1), the BSF process allocated considerable power to the Building Contractor and therefore put the Architect in a position where the key decisions were in the hands of the Contractor. Indeed the Architect's role was largely seen by other members of the team to focus on the aesthetical quality of the bid and it was the Contractor who dictated the building specification and, hence, its energy performance. The Contractor's interest, on the other hand, was largely seen to predominantly win the bid and then deliver the minimum sustainability requirement with the least investment. The Project Architect (2) similarly highlighted this conflict of objectives between designers and contractors when she said:

> Because obviously contractors are looking at it financially, while you're looking at it as it's your baby, your design, you're looking at it more like 'We want to have the best job, we want to create a beautiful school for these kids that they can enjoy' and I think a lot of contractors don't, they want to achieve a great building at the end of the day but their priorities are cost and time (Project Architect [2]).

ProjectCo actors also highlighted the important issue of the nature of the ProjectCo's contractual commitment and the organisations involved in this commitment for the delivery of a sustainable and energy-efficient building. On SVC, the Building Contractor was Miller construction and Facility Manager was G4S, a company which partnered with Miller during the pre-qualification stage. The effectiveness of this arrangement, according to FM Design Coordinator, was that the Facility Manager could hold the Building Contractor accountable if any faults were identified during the initial operational stages of the facility. This conflict of interest between the Building Contractor and

Facility Manager was seen to be important in PFI. However, the Building Contractor's Operations Manager did not share this viewpoint. According to the Building Contractor's Operations Manager, as far as the Building Contractor was concerned, their role was ultimately to deliver the client requirement and then hand the building over to the Facility Manager at the end of the initial period. It was for the Facility Manager to decide whether assuming the responsibility for the building for the next 25 years was worthwhile. While the Building Contractor was responsible for design risk in the initial period, it was the Facility Manager who was assuming the long-term risk of providing the client with a serviceable, well-maintained building for the duration of the concession period. This viewpoint may substantiate concerns raised by the LA Sustainability Manager who argued that lack of interest in energy issues is due to the fact that Contractors' main responsibility is constructing the building and then handing it over to the Facility Manager to operate. Since the Facility Manager is the one responsible for energy consumption, innovative energy solutions that are likely to result in higher initial cost for the Building Contractor are often not welcomed. There is little incentive for the Building Contractor to achieve outstanding results for energy efficiency, given that the standards delivered meet the client requirement.

In conclusion, Proposition 2 is not supported on the case study project. Effective communication and collaboration with Facility Management was constrained by the fact that Facility Management worked for the ProjectCo, so they were one step removed from the Design Team. The Facility Management team had a limited degree of participation during the bidding phase due to the limited resources allocated for this phase of the project. In addition, the case study findings may indicate that the separation of companies responsible for construction and those responsible for operation might not be conducive to SEI. As the Building Contractor carried no operational risk, they were not incentivised to improve the energy performance of the building beyond minimum requirement. The Architect was also restricted by the considerable power allocated to the Building Contractor under the D&B contract. The Architect was in a position where key decisions on sustainability were in the hands of the Contractor. The Contractor's interest, on the other hand, was largely seen to predominantly win the bid and then meet the minimum sustainability requirement with the least investment.

7.3.3 Proposition 3: Findings

The study's third proposition advances that SEI is supported by open communication and effective collaboration during BSF Local Authority-ProjectCo engagement processes. This section will discuss the extent to which this conceptual proposition translated into experienced reality in supporting the implementation of SEI during the design development stages of SVC. The case study findings will be discussed under two headings: (1) Openness of communication (Box E2.3.1); and (2) Effectiveness of collaboration (Box E2.3.2).

1. Openness of Communication

During the competitive dialogue process, communication between the ProjectCo and the sustainability expertise within the Local Authority was managed by the Local Authority's Core Team and the ProjectCo Bid Management Team. These single points of contact were seen by both ProjectCo and Local Authority actors to be effective in facilitating clear information flow. However, as shown in Box E2.3.1, several issues were highlighted by both ProjectCo and Local Authority actors as constraints to their communication. First, the nature of BSF engagement processes was highly restricting. Engagement processes were in large forums with many stakeholders involved. Communication was difficulty because it had to be equal and uniform across all bidders. Second, both the ProjectCo actors and the Local Authority's Sustainability Expertise felt the engagement process was tightly managed by the Core Team. There was a general lack of recognition within the Core Team of the intensity and volume of work needed to manage the BSF programme. Because Leicester was one of the early BSF bids, the Core Team was seen not to be aware of the amount of consultation needed. The LA Environment Team and the Sustainability Manager in the Education Department were not involved with bidders and were unable to challenge bidders' proposals. The LA Energy Team, Property Services, and Planning Department were also absent from initial engagement meetings. The Core Team working autonomously from other parts of the Local Authority made it difficult for the ProjectCo to ensure that the designs delivered all stakeholders' objectives. According to ProjectCo Bid Manager, the process could have benefitted from better coordination of all the different elements within the Authority so as to make sure their goals fed through in a 'one team' approach.

Midway through the engagement process, some parts of the Local Authority raised concerns that there was a lack of representation of the Authority's interest within the engagement process. Several members of the Property Services Team were then invited to take part as delegates for the schools during engagement meetings. However, their role was restricted to observing discussions and taking minutes of meetings and they were discouraged from contributing to the development of the schemes. Moreover, there was lack of initiatives that required the ProjectCo to liaise directly with the Authority's representatives dealing with sustainability. Some communication took place with planners regarding energy efficiency as part of the planning application. However, once the criteria were met and an energy statement included with the planning application, planners were satisfied and no longer involved. This lack of communication resulted in Local Authority representatives being seen to be unsure about their requirement. Indeed, the ProjectCo Bid Manager argued that there was an absence of effective dialogue to achieve clear commitment to realistic sustainability targets. In addition, the engagement process provided limited opportunities to build a close relationship between the Design Team and the Local Authority. Because the Design Team was appointed by the Building Contractor from an early stage, their communication with the Local Authority tended to be through the Contractor. As the M&E Engineer commented:

> But it is nice to have that direct communication because, at the end of the day, most people within the construction industry are genuinely trying to deliver the best building they can. And with the best will in the world, if you can't talk directly to the client openly about what it is they want and understand that in the first instance, you are then struggling, if you like, to try and design a response to precisely what they want if your communication is only through technical documents (M&E Engineer).

In addition, the fact that design was running concurrently with bidding meant that the aesthetics of the design were considered equally important to its energy efficiency. The limited budget available meant that a compromise was needed between achieving an award-winning[6], aesthetically pleasing design, and a sustainable design. As the ProjectCo Bid Manager puts it:

> So, you invest a fair bit in the design to make it a winning design, rather than what's under the skin and can't be seen. As it's a competition, a lot of the people who are looking to score your presentation are looking at the design and the

[6] SVC was shortlisted in the 'Most inspirational use of outside space' category in the 'National 2009 Excellence in BSF' Awards.

> impact of the design and how people will interact with that design, rather than looking at the base data of the energy it is going to use ... By its very nature, the low-energy design dictates that it's not going to have huge areas of glass and big wow factors, it's going to be a conservative design. And in a competition people don't want a conservative design; they want something that's going to shout out! (ProjectCo Bid Manager).

The ProjectCo was selected as the Preferred Bidder in September 2006. During this stage, representatives from the Environment Team, the Energy Team, and the Sustainability Manager from the Education Department were introduced to work with the ProjectCo on the sustainability proposal. The Local Authority representatives tried to push the sustainability agenda as far as possible but were constrained by the affordability envelope. The Local Authority representatives also struggled to meet the needs of these engagement meetings on top of their main job responsibilities. The involvement of Property Services was somewhat extended after being appointed as an Internal Technical Advisor during the Preferred Bidder stage to carry out their 'due diligence' on the ProjectCo's designs. This involvement was interrupted throughout the process due to arguments over fees and capacity. The ProjectCo actors were disappointed by the late involvement of the LA Property Services Team, which insisted on many design changes at a very late stage. The period leading to planning permission was, therefore, difficult. Moreover, the bidding phase was limited to 12 weeks in which consortia had to 'go from a blank sheet of paper to designing all four schools'. According to ProjectCo Bid Manager this was 'ridiculously short' and was reflected in the low quality of bids the Local Authority received. The desire to start on-site as early as possible meant the Authority reached Financial Close without having a full set of plans and drawings, with assurances made by the ProjectCo that design data would be forthcoming. This resulted in a complicated construction process in which design issues were being resolved as the projects were being constructed on-site.

2. Effectiveness of Collaboration

Collaborative working between ProjectCo and Local Authority actors, as shown in Box E2.3.2, was highly restricted. The Local Authority's requirement of zero-carbon schools was seen by ProjectCo actors to be unrealistic both technically and financially at the time, and was seen to partly stem from Local Authority actors' lack of appreciation of the limited budget available. On the other hand, Local Authority representatives felt they had no power or influence throughout the process with the project dominated by the ProjectCo. Once the ProjectCo had been awarded Preferred Bidder status, they were the drivers of the project and were taking the lead on sustainability issues. That said, the ProjectCo main objective was seen to meet the BREEAM requirement with the least cost, in order to increase its profitability. ProjectCo actors were also seen to be relatively inflexible to the Authority's requirements and were pushing through with decisions. Issues raised by the Local Authority were dealt with through compensation rather than being adequately addressed and corrected. As the LA Internal Technical Advisor explains:

> It was almost a case of 'We want to get on and build it and you're going to get what you're given!' They *(referring to ProjectCo actors)* just steamrolled stuff through, and it was quite an uncomfortable situation for certain members within the Authority because although you were there and meant to be actually technically reviewing schemes, regardless of whether or not you came with issues, in the majority of cases the Contractor bulldozed them through. And when they were taken to task over it, it was either settled by financial means rather than actually rectifying the issues that had been raised. And I don't think we, at that time, we had any teeth whatsoever really. We were just seen as being the technical reviewer. We raised an issue but we had no actual clout to get stuff changed (LA Internal Technical Advisor).

In conclusion, Proposition 3 is not supported in this case study project. Open Local Authority-ProjectCo communication was constrained by the lack of recognition within the Core Team of the intensity and volume of work needed to manage the BSF programme. The engagement process was tightly managed by the Core Team and the key sustainability expertise was not involved in consultation with bidders. The depth and quality of the information received from the Local Authority during the engagement process was thus unsatisfactory. Joint Local Authority-ProjectCo collaboration was restricted by misalignment of objectives between ProjectCo and Local Authority actors. Local Authority representatives were seen to lack appreciation of budget constraints. Indeed, the requirement for zero-carbon schools was seen to be unrealistic both technically and financially at the time. On the other hand, Local Authority representatives felt they had no power or influence throughout the process with the project dominated by the Contractor. The Contractor's main objective was seen to meet the minimum requirement, with the least cost.

7.3.4 Proposition 4: Findings

The study's fourth proposition advances that SEI is supported by open communication and effective collaboration during BSF School-ProjectCo engagement processes. This section will discuss the extent to which this conceptual proposition translated into experienced reality in supporting the implementation of SEI during the design development stages of SVC. The case study findings will be discussed under two headings: (1) Openness of communication (Box E2.4.1), and (2) Effectiveness of collaboration (Box E2.4.2).

1. Openness of Communication

After being issued with the ITCD documentation, bidders were invited to respond to the Local Authority's Requirement. Bidders' proposals were then tested against the Local Authority's requirements in a series of stages and gateways. The three bidders were also invited to participate in dialogue with the four schools involved in this phase of the BSF programme, including SVC. Communication between bidders and public sector clients (the Local Authority and Schools) was organised by the Core Team. Bidders' teams were headed by Bid Management teams, which acted as their interface with the Local Authority and schools. The objective of the engagement process was for Bidders' Design Teams to understand the School's needs and aspirations. All parties concerned in the School—student, management team, teaching and support staff and governors—participated in the engagement meetings. A series of six engagement meetings was organised by the Core Team, held once every week for a period of six weeks. Engagement meetings were organised to ensure equal treatment, non-discrimination, and transparency among all bidders. Meetings were attended by the ProjectCo's engagement team, which included the Bid Manager and representatives from the Building Contractor, Architect, and M&E Engineer. The Design Team presented design development proposals for students in the various age groups as well as staff at different levels.

As shown in Table F2.4.1, effective engagement between the ProjectCo and the School community was supported by a committed School Engagement Team. Both the School's Head Teacher and Business Manager were strongly committed to the BSF process and were strongly involved throughout the process. BSF was seen as a unique opportunity to radically change the lives of their students and the community they serve.

However, as shown in Box E2.4.1, several issues were raised by ProjectCo Actors regarding the effectiveness of their engagement with the School. First, the engagement process was seen to be ‘difficult’ and ‘restricted’. Consultation meetings were tightly managed by the Core Team to allow the same amount of time for each bidder. The School was briefed to be impartial and equal to all bidders. Second, the Design Team was working under the Building Contractor from an early stage and, therefore, their direct communication with the School was somewhat constrained. Third, while the School was satisfied with the level of engagement and involvement that they had throughout the process, the engagement process was seen to be massively time-consuming and exhausting to the School Engagement Team. The School’s Head Teacher and Business Manager had to attend a massive amount of meetings with the three shortlisted Bidders. They were also expected to continue in their daily responsibilities of managing the School while going through the BSF process, which put immense pressure on the team. The School Engagement Team also attended numerous meetings with individual members of the ProjectCo, such as specific meetings with the Design Team, Contractor, ICT, and Facility Management. This complicated communication and resulted in many coordination problems.

Communication between the ProjectCo and the School greatly improved after the appointment of the Preferred Bidder. The Architect was able to visit the School outside the set consultation time which improved communication and collaboration. However, the School was frustrated in that many of the individuals that formed the ProjectCo Bid Team moved to work on other bid projects and were replaced by new personnel. The new personnel responsible for delivering the project had no history of dealing with the School and lacked adequate understanding of what was promised during the bid. The School Business Manager highlighted his frustration in that many of the promises made during the bid were not delivered afterwards. As described by the School Business Manager:

> This is the story of BSF, the stress and amount of time it takes, for instance, me and the Head, is frightening, absolutely frightening. To do everything three times, looking back we … I would say that, how do I put this? We were fed a lot of, I won’t use the word bullshit but there were a lot of promises made in that process that don’t make their way through to the final (School Business Manager).

2. Effectiveness of Collaboration

The School interest in sustainability as a learning resource was seen as the main driver for effective collaboration towards an environmentally friendly solution. The School saw the pursuit of a sustainable solution as an opportunity to enrich the curriculum and allow its pupils to experience renewable energy technologies first-hand. The role of the School as a beacon for sustainability within the wider community was also appreciated. The School was particularly interested in the installation of BMS (Building Management System) to monitor its energy consumption. This allows students to view their energy usage by logging into a dedicated website and comparing their consumption with other schools. A small amount of Photovoltaic and Solar Panels was also installed for educational purposes.

However, as shown in Box E2.4.2, several issues were raised by ProjectCo Actors regarding the effectiveness of their collaboration with the School. First, the School's priority was fundamentally their educational requirements. According to the Building Contractor's Operations Manager, Schools generally are consumed with their own business of managing the School and the stringent targets that need to be met, in terms of results and curriculum. Sustainability through the construction was not necessarily high on their priority list. Second, the conflict between transformational learning aspiration and energy-conscious design was also seen as a key concern. The new design of SVC includes large social spaces for the students to enjoy. These spaces were well-liked by the School community and aligned with their transformational learning aspirations. However, the large spaces resulted in the building being 200m^2 in excess of Building Bulletin 98 (BB98) area requirement. The larger area also meant higher lighting and heating demands, which contradicted the energy efficiency objective. Third, due to the limited BSF budget, there was conflict between the School's requirement and the requirements for sustainability. In fact, during affordability negotiations, some sustainability elements were engineered out. Originally, there had been plans to develop a Virtual Energy Centre in the School with a collection of renewable energy technologies on display. Although the technologies were rather tokenistic with no real impact on energy generation, they were intended to serve as a learning resource for students. However, during affordability negotiations the School decided to use the budget allocated to the Virtual Energy Centre on other requirements and the concept was consequently abandoned.

In conclusion, Proposition 4 is not supported in this case study project. School-ProjectCo communication during the early design development stages was somewhat constrained by the formal nature of BSF engagement and the limited time allocated to the process. The Engagement process was tightly controlled by the Core team and massively time-consuming and exhausting to the School. School-ProjectCo collaboration towards SEI was also restricted by the low priority of sustainability and energy issues to the School.

7.3.5 Proposition 5: Findings

The study's fifth proposition advances that SEI is supported by clear, appropriate, and manageable allocation of the risks associated with the project's energy performance. This section will examine the extent to which this conceptual proposition translated into experienced reality in supporting the implementation of SEI during the design development stages of SVC. The case study findings will be discussed under three headings: (1) Clarity of risk allocation (Box E2.5.1); (2) Appropriateness of risk allocation (Box E2.5.2); and; (3) Manageability of risk allocation (Box E2.5.3).

1. Clarity of Risk Allocation

The energy strategy adopted on SVC was largely driven by the allocation of several energy-related risks to ProjectCo actors. Particularly important to ProjectCo actors were: *availability risk, planning approval risk* and *energy consumption risk*. The availability risk relates to the building environment not meeting agreed criteria and thus incurring availability penalties. As part of the PFI contract an 'Availability Clause' is linked to the Payment Mechanism in which a fine is levied for unavailability of any teaching spaces that exceed 28°C for more than 120 hr/yr (based on BB101 – Ventilation of School Buildings). *Planning approval risk* refers to the energy solution adopted failing to meet a number of criteria, including Leicester's planning requirements of 11% on-site renewable energy generation. *Energy consumption risk* is the risk that the building's operational energy consumption is beyond agreed standards for maximum annual energy consumption in the contract. These three types of risk were seen as the major drivers for the energy solution. The team also managed a number of other risks such as *BREEAM target risk*: the risk that the building fails to achieve the BREEAM 'Excellent' target and hence incurring penalties; *technical risk*: the risk that the solution adopted fails to meet technical criteria; and *capital cost risk*: the risk that the solution adopted is too expensive and hence rejected by the client.

As shown in Box E2.5.1, ProjectCo actors agreed that the high-level risks related to energy were made clear within the BSF contract and there is little controversy over their allocation. However, it was the Building Contractor's lack of understanding and assessment of the allocated risks, particularly those related to the BREEAM 'Excellent' requirement, which complicated the process. Being their first BSF scheme, the Building Contractor lacked adequate understanding of their commitment to the Local Authority and the impact that a BREEAM 'Excellent' requirement could have on project costs and time constraints. Indeed, post-Financial Close, as there were penalties associated with the achievement of BREEAM 'Excellent' rating, the amount of effort needed to achieve it was a considerable challenge to the Building Contractor.

2. Appropriateness of Risk Allocation

As shown in Box E2.5.2, ProjectCo actors unanimously agreed that risk allocation associated with the project's energy performance was considered appropriate. Contractually, meeting the Availability Clause was the responsibility of the ProjectCo SPV as part of the BSF PFI contract. Within the ProjectCo, the Building Contractor was responsible for the design and construction of the building meeting the energy targets for the initial period. The Facility Manager assumes both energy consumption and energy tariff risk for the first three years. Following this, energy consumption becomes the responsibility of the Facility Manager, while the Local Authority retains the risk on tariff.

3. Manageability of Risk Allocation

The availability risk was identified and evaluated early in the design process and the financial penalties associated with it were deemed sufficiently important to influence the design process. The Availability Clause was a new concept to the Design Team, which had to design differently from traditional projects. The Design Team needed to meet the availability criteria without increasing the energy consumption of the building beyond permitted limits. To reduce the building's energy demand, the Design Team worked on optimising passive design principals such as orientation, classroom positioning, and reducing solar gain. Improvements to the building's fabric were also sought and the team was able to achieve a small improvement to building regulation and deliver air leakage of $5m^3/m^2$ compared to the $10m^3/m^2$ required by regulation. To ensure the building's internal environment was comfortable for the School, a mixed-mode ventilation strategy was adopted with a mixture of natural ventilation in the majority of classrooms and mechanical ventilation in some of the larger spaces, such as the dining hall and kitchens.

However, the team was faced with considerable challenges when trying to meet the BREEAM 'Excellent' requirement. As mentioned earlier, being their first BSF scheme, the Building Contractor had limited understanding of the financial and cost implications of pursing a BREEAM 'Excellent' rating. Following Financial Close, the BREEAM 'Excellent' requirement introduced considerable challenges during the detailed design process. Project Architects (1) (2) were not involved in Financial Close negotiations, and felt that their presence could have clarified many ambiguities in the contract. Eventually, the requirement was met in close collaboration between the Architect, M&E Engineer, and an external BREEAM consultant, appointed by the Building Contractor as a 'BREEAM Policeman'. However, according to the Project Architect the process to secure the BREEAM 'Excellent' requirement was 'tedious and time-consuming'.

The design process was further complicated by the ProjectCo's decision to demolish and rebuild one of the other schools originally intended for refurbishment, Beaumont Leys School[7]. This was largely decided to improve the energy performance of the School and an 'Excellent' BREEAM rating was equally achieved. As ProjectCo Bid Manager explains:

> We consider we're better off trying to build a low-energy solution to start with. So rather than take a rubbish building and bolt on lots of nice wind turbines and heat pumps and everything else, we'd rather take the money and say, 'Right, well can we build it new instead?' because it's going to be far more efficient than an old building (ProjectCo Bid Manager).

However, the decision to rebuild Beaumont Leys School put the ProjectCo at the limit of affordability on all four schools. Due to budget constraints, the Local Authority requirement of 11% on-site renewable energy generation was difficult to implement on each of the four school sites involved, jeopardising the team's ability to obtain planning permission. After lengthy discussions with planners, a decision was made to take a portfolio approach to the target by focusing on the two new-build PFI projects, SVC and Judgemeadow Community College, achieving a 20% on-site

[7]Interestingly, the new Beaumont Leys School went on to win the 'Grand Prix' and 'BSF School of the Year' awards in the National 2009 Excellence in BSF Awards.

renewable energy generation on each. To develop the 20% renewable energy solution, the Design Team evaluated the technical risks associated with several technology options. A wind turbine was initially considered but was abandoned due to planning approval issues. There was a need for the technology to be robust and to last at least for the 25 years of the concession in order to satisfy investors and limit the risks carried by the ProjectCo. Pursuing innovative and new technologies was seen to increase the risk to the ProjectCo and technologies with a well-proven track record were deemed easier to adopt. Consequently, the team decided to pursue a conformance-based strategy based on Biomass Boilers, which were considered the safest and most cost-effective means of meeting the target.

In conclusion, Proposition 5 is not supported in this case study project. Clarity of risk was an issue on this project with the Building Contractor lacking adequate understanding and assessment of the risks associated with the BREEAM target. This complicated the design process. In addition, excessive perceived technical and capital cost risks led to the adoption of a well-known technology with a proven track record and cost-effectiveness in the form of the Biomass Boiler.

7.3.6 Proposition 6: Findings

The study's sixth proposition advances that SEI is supported by incentive-based payments linked to the project's energy performance. This section will examine the extent to which this conceptual proposition translated into experienced reality in supporting the implementation of SEI during the design development stages of SVC. The case study findings are shown in Box E2.6.1.

Leicester City Council adopted the standard BSF contract and Payment Mechanism in its contract with the ProjectCo. Energy efficiency is part of the efficiency in the Facility Management service contract and is part of the unitary charge for the PFI contract. The standard BSF mechanism dictates that the Facility Manager operating the School takes the risk on both energy consumption and tariff for the first three years. During this period the energy performance of the building is monitored by the Facility Manager. At the end of this period, energy consumption is benchmarked and the Facility Manager subsequently takes the risk on consumption while the Local Authority takes the risk on tariff. This re-benchmarking procedure is scheduled to take place every three years. The ProjectCo compares its prices for energy to the price of equivalent service provision in the market. Subsequently, the corresponding part of the Unitary Payment is adjusted according to a pre-agreed formula. The ProjectCo can reap the benefit of any cost savings as a result of introducing energy-saving systems and strategies within the utility period before energy consumption is re-benchmarked.

Both Local Authority and ProjectCo actors, as shown in Box E2.6.1, highlighted the deficiency in the BSF contract to provide the private sector with adequate incentive to improve the energy consumption of the building post-contract. According to LA BSF Project Manager, a major shortfall in their long-term contract with the ProjectCo and Service Provider was that the contract offered limited incentive to the ProjectCo to introduce energy efficiency measure post-handover. The limited time allowed for the ProjectCo to reap the benefit of introducing technologies post-contract, before energy performance of the building is re-benchmarked, discourages the introduction of high-cost technologies with long payback periods. This is because ProjectCo actors will hardly reap any benefits from doing so. This frustration was echoed by ProjectCo actors. According to ProjectCo Bid Manager, although PPPs were supposed to strengthen the capacity and expertise within the private sector, they were almost excluding it by adopting such models. This was particularly frustrating because new technologies are continuously emerging which could considerably reduce the energy-consumption of the building. According to the ProjectCo Bid manager, under the current BSF contract, introducing innovative energy-efficient technologies post-contract could only be worthwhile if funding for such technologies was provided by the Local Authority. In that case, they could continually reap its energy efficiency benefits.

In conclusion, Proposition 6 is not supported in this case study project. The continuous benchmarking of energy consumption every three years limited the incentive for ProjectCo actors to strive for continuous improvements of the project energy consumption.

7.4 Summary

The aim of this research study is to develop an understanding of the capacity of the PFI project delivery model to support the implementation of SEI on BSF new-build school buildings. This Chapter discussed the extent to which six conceptual propositions have translated into experienced reality in supporting the implementation of SEI during the design development stages of SVC. The main case study findings are as follows:

1. Proposition 1 was not supported. While the output-based nature of the requirement offered the team with the flexibility to suggest innovation, it provided limited incentive to do so. The achievability of the requirement was questionable and Local Authority representatives were seen to lack adequate understanding of their requirement. The requirement for zero-carbon schools was seen to be unrealistic both technically and financially at the time. In addition, while BREEAM was seen as the major driver for sustainability on this project, BREEAM does not ensure an energy-efficient building. The low weighting of sustainability in bid evaluation also offered limited incentive for the ProjectCo to pursue SEI.

2. Proposition 2 was not supported. Effective communication with Facility Management was constrained by the fact that the Facility Management team worked for the ProjectCo, so they were one step removed from the Design Team. The Facility Management team had a limited degree of participation during the bidding phase due to the limited resources allocated for this phase of the project. In addition, the case study findings indicate that the separation of companies responsible for construction and those responsible for operation may not be conducive to SEI. As the Building Contractor carried no operational risk, they were not incentivised to improve the energy performance of the building. Innovative energy solutions which were likely to result in increased initial capital cost to the Building Contractor were thus not welcomed. The Architect was also restricted by the considerable power allocated to the Building Contractor under the D&B contract. The Architect was in a position where key decisions on sustainability were in the hands of the Contractor. The Contractor's interest, on the other hand, was largely seen to win the bid and then meet the minimum sustainability requirement with the least investment.

3. Proposition 3 was not supported. Effective Local Authority-ProjectCo communication was constrained by the lack of recognition within the Core Team of the intensity and volume of work needed to manage the BSF programme. The engagement process was tightly managed by the Core Team and the key sustainability expertise was not involved in consultation with bidders. The depth and quality of the information received from the Local Authority during the engagement process was thus unsatisfactory. Effective Local Authority-ProjectCo collaboration was restricted by Local Authority representatives' lack of appreciation of budget constraints. The requirement for zero-carbon schools was

seen to be unrealistic both technically and financially at the time. On the other hand, Local Authority representatives felt they had no power or influence throughout the process with the project dominated by the Contractor. The Contractor's main objective was seen to meet the minimum sustainability requirement, with the least cost.

4. Proposition 4 was not supported. School-ProjectCo communication during the early design development stages was somewhat constrained by the formal nature of the engagement and the limited time allocated to the process. The Engagement process was tightly controlled by the Core team and massively time-consuming and exhausting to the School. School-ProjectCo collaboration towards SEI was also restricted by the low priority of sustainability and energy issues to the School.

5. Proposition 5 was not supported. Clarity of risk was an issue on this project with the Building Contractor lacking adequate understanding of the risks associated with the BREEAM target. This complicated the design process. In addition, excessive perceived technical and capital cost risks led to the adoption of a well-known technology with a proven track record and cost-effectiveness in the form of the Biomass Boiler.

6. Proposition 6 was not supported. The continuous benchmarking of energy consumption every three years limits the incentive for ProjectCo actors to strive for continuous improvements of the project's energy performance.

Chapter 8: Case Study 3

Image 8.1: HGS: Aerial View
Courtesy of BDP (2009)

This Chapter presents the findings from Highbury Grove School (HGS) case study. The Chapter is divided into four sections. The first section provides a brief introduction to the project, the Sustainable Energy Innovation (SEI) implemented, and the project's sustainable energy design features. The second section outlines the key sources of data. The third section explores the case study findings based on the six propositions developed in Chapter 4. The fourth section offers a concluding summary of the case study's findings.

8.1 Introduction

HGS is one of four schools[8] in the first phase of the London Borough of Islington's £140m Building Schools for the Future (BSF) programme. It is a £30m new-built mainstream secondary school for

[8] The other three schools are Samuel Rhodes MLD Secondary School, St Aloysius Roman Catholic Boys School, and Holloway School.

1200 pupils aged 11–19. The existing school building dated back to 1902 with the majority of the building completed in the 1960s. The piecemeal pattern of development, coupled with the physical constraints of the out-dated buildings, had meant that the school buildings had in effect reached the end of their useful life and were in desperate need of development.

The new HGS development was part of Islington's 'Sample' schemes, one of four School projects that the Council went to market with when procuring their BSF programme and was designed as part of a competitive dialogue process. Islington OJEU notice was published in May 2006 and Preferred Bidder was selected in May 2007. The Council's Preferred Bidder, Transform Schools, was a Consortium comprising Balfour Beatty Investments/Barclays Capital (Equity Providers), Balfour Beatty Construction (Building Contractor), Building Design Partnership (Design Consultant), Balfour Beatty Workplace (Facility Manager) and Research Machine (ICT). Financial Close was reached in July 2008 creating Islington's Local Education Partnership (LEP). Construction on-site started in February 2008 under an Advanced Work Agreement and the new School was opened in January 2010.

Image 8.2: HGS: Natural Lighting
Courtesy of BBCap (2010)

HGS was selected as a case study for its innovative sustainable energy supply strategy utilising high-end technologies (mini-Combined Heat and Power Plant, Ground Source Heat Pump, Earth Tubes, and mini-Wind Turbine) to offset and reduce carbon emissions and provide micro-generation. The range of renewable and low-energy technologies was designed to provide flexibility and spread energy risk among the different energy providers and users within the School. The core engineering design is based on multiple low-energy features: displacement cooling with energy-efficient variable air volume control; low-energy computer specifications; occupancy sensing for heating, ventilation, and lighting; and high building fabric specification. The School was designed to be an 'exemplar' for sustainability and achieved an 'Excellent' BREEAM rating. The School was also the runner-up in the 'Most Sustainable School Design' category in the 'National 2008 Excellence in BSF' Awards. It was also one of the first BSF School projects in the country to deliver more than 20% renewable energy from on-site sources. The School design achieved a 61% reduction in CO_2 emissions against Part L 2002 Building Regulation and 25.3% reduction against Part L 2006 Building Regulation. The School's key sustainable energy design features are outlined in Figure 8.1.

Figure 8.1: HGS Sustainable Energy Design Features

Energy Efficiency:

The new school building is designed and built to reduce energy demand relative to current Part L 2002 standards through use of passive design features such as:

- **Improving the Building Fabric:** The School's design incorporates exposed thermal mass in all classroom spaces to maximise the effect of night-time cooling. An air-leakage rate of $10m^3/m^2/s$ has been specified to comply with building regulations. U-values at 10% better than 2002 building regulations have also been specified. Green roofs will add thermal mass to the building and will act as additional insulation for the building.
- **Lighting:** The School is designed to have daylight factors greater than 2% within teaching spaces.
- **Ventilation:** Specific site constraints led to a large proportion of the School being mechanically ventilated. However, the integration of earth tubes into the design significantly reduced the energy demand from the heating and cooling plant.

Renewable Energy:

The renewable energy target for 20% was met through the following means:

- **Ground Source Heat Pumps:** The system consists of 23 vertical boreholes giving a total output of 150kW. The system will simultaneously provide heating and cooling, serving ICT cooling units and classroom AHU cooling coils whilst providing hot water to the under-floor heating systems and swimming pool AHU heating coil.
- **Earth Tubes:** The earth tubes provide pre-tempering of air in winter and a degree of cooling during the summer, thus further reducing the energy loads from active heating and cooling plant.
- **Demonstration Wind Turbine**: A small demonstration wind turbine (3.5m diameter) will generate 0.2% of the site's energy, and will be located in the centre of the site for educational purposes.
- A small gas-fuelled Combined Heat and Power plant (CHP) is used to heat the existing swimming pool, further reducing the CO_2 footprint.

The School design achieved 61% reduction in CO_2 emissions (against Part L 2002 Building Regulation)

Source: Developed for this research study

8.2 Case study Participants

Data collection for this case study involved 12 semi-structured interviews with key project stakeholders. Table 8.1 lists the actors that took part in the research study. It describes each interviewee in terms of his/her respective organisational team and the interviewee position within the team. (Please refer to Table 5.4 in Chapter 5 for a description of how stakeholders were selected to be included in the study, including a description of their role and responsibilities). It also outlines the title used to refer to the interviewee within the case study findings.

Table 8.1: HGS Case Study Participants

Team	Interviewee	Title used to refer to interviewee within the case study findings	Ref.
The Local Authority: The London Borough of Islington (LBI)			
BSF Management Team	Project Manager	LA BSF Project Manager	L1
Sustainability Unit	Head of Sustainability	LA Head of Sustainability	L2
Energy Management Unit	Energy Manager	LA Energy Manager	L3
Planning Department	Senior Planning Officer	LA Planning Officer	L4
Technical/ Design Advisor	Technical Advisor	LA Technical Advisor	L5
The ProjectCo: Transform Schools			
Bid Management Team	Assistant Bid Manager	ProjectCo Assistant Bid Manager	P1
	Whole Life Cost Director	ProjectCo WLC Director	P2
Building Contractor (Balfour Beatty)	Operations Manager	Building Contractor's Operations Manager	P3
Architect (BDP)	Project Director	Project Architect	P4
M&E Engineer (BDP)	Project Engineer	M&E Engineer	P5
Facility Manager (Balfour Beatty)	Operations Manager	FM Operations Manager	P6
The School: HGS			
School Engagement Team	Head Teacher	School Head Teacher	S1

Source: Developed for this research study

8.3 Case Study Findings

This section will present findings from HGS case study. The case study findings are divided into six subsections according to the six research propositions developed in Chapter 4. Table E3 in Appendix E reviews the key findings for each proposition. The table summarises emergent issues for each conceptual construct (defined in Table 5.6 of Chapter 5), synthesised from the 12 case study interviews, and demonstrates the theory underlying the empirical findings. Effort was made to tie the Box related to each theoretical construct clearly to the text. Each proposition subsection is also illustrated with quotes from the case study interviewees.

8.3.1 Proposition 1: Findings

The study's first proposition advances that SEI is supported by the greater clarity of the sustainable energy requirement and governing framework in BSF PFI Output Specification. This section will discuss the extent to which this conceptual proposition translated into experienced reality in supporting the implementation of SEI during the design development stages of HGS. The case study findings will be presented under three headings: (1) The development of the sustainable energy requirement; (2) Clarity of the sustainable energy requirement (Box E3.1.1); and (3) Clarity of the governing framework (Box E3.1.2).

1 The Development of the Sustainable Energy Requirement

The London Borough of Islington is a BSF 'Wave 2' Local Authority. Islington's approach to managing its BSF programme was to build a team that transcended organisational boundaries. The Core BSF Project Management Team (referred to as the Core Team in the remainder of this Chapter) included a Project Director and a Project Manager. The Core Team then sought specialist knowledge and advice from across the Local Authority when and where it was needed. The view was that BSF was an Islington-wide programme and should be supported across the Local Authority. The merit of this arrangement was that project team members were outsourced from their own departments, thus were not line-managed or funded by the Core Team. Outsourced members were also supported by their departmental colleagues in terms of expert knowledge and advice. Occasionally, however, outsourced members found it difficult to prioritise BSF assignments above their departmental responsibilities.

The overriding objective of Islington's BSF programme was to transform educational delivery in the Borough. BSF was seen as an once-in-a-lifetime opportunity to design, build, and maintain schools that will deliver integrated services and which are focused on the needs of children, their parents/carers, and the wider community (LBI, 2006). As the Council stated, 'Through the provision of a modern, welcoming, clean and technology-integrated environment, it is hoped that Secondary School pupils will see and experience the value being placed upon them and thereby gain in self-worth and esteem' (LBI, 2006, p.5).

In addition, the Local Authority saw the pursuit of a sustainable solution as paramount to achieving its '*One Islington*' vision. The Local Authority vision was:

> To make Islington a greener place to live and work, a place where people of all background are able to achieve their full potential, and a borough of safe, thriving and active communities, where people are involved in the decisions that affect their life (LBI, 2006, p. 6).

According to Islington's BSF Memorandum of Information (MOI) (LBI, 2006) Islington's corporate priorities that aim to deliver this vision are 'customer focus; regeneration and sustainability'. As Islington's BSF MOI (LBI, 2006) states, 'Islington Council is committed to creating a borough that is environmentally sustainable. The Council seeks to minimize harmful impacts on the environment and to create greener, cleaner and healthier place to live and work' (p. 8). The pursuit of sustainability within Islington BSF was motivated by three principal factors. First, Liberal Democrats ran Islington Council and their sustainability agenda greatly affected the Council's policies. Multiple environmental strategies such as energy, transport, materials, and biodiversity were woven into planning policies and guided the development of major projects. The second motive was regional policies such as the London Plan which sets overreaching design principles for London. Renewable energy was an important issue at the time the project was developed and there was a requirement of 10% on-site renewable energy generation on all major developments. Finally, national polices in relation to sustainability were also taken into consideration, and Islington Council understood the need for good green credentials alongside such a huge investment such as BSF.

To develop the Output Specification, the Core Team put together a Technical Team led by an external Technical Advisor. The Technical Team was responsible for putting together the Output Specification, including the sustainability requirements. On the Technical Team sat the Head of the Sustainability Unit, responsible for implementing sustainability on the project. Also sitting on the Technical Team was the Senior Energy Manager from Islington Energy Centre as well as the Senior Planning Officer. The School's Engagement Team, including the Head Teacher, Deputy Head, and Business Manager, were also involved and were leading their detailed requirements, guided by their Education Advisor (Cambridge Education Authority). The Technical Team met regularly to draft the Output Specification. The role of the Sustainability Unit was particularly important during this stage. The Sustainability Unit worked closely with the Core Team and acted as the primary source of sustainability knowledge and expertise to the Technical Team, as well as to other stakeholders within the Local Authority. The presence of the Sustainability Unit as a knowledge base also meant that other parts of the Local Authority were comfortable with sustainability decisions made because they were taken from within the Local Authority. Moreover, the extended time span of the BSF process was seen to allow the Local Authority some ‘breathing space’ to develop their requirements and become an educated client before bidders got involved. Many compromises were made when writing the sustainability requirement in order to deliver the objectives of the multiple stakeholders involved within the Local Authority.

The Output Specification followed the standard documentation format provided by PfS. The Output Specification was fundamentally a large set of documents outlining the Local Authority’s BSF strategic objectives, facilities’ requirements, services specification, performance requirements, and availability criteria. It also included annexes outlining statutory requirements in terms of statutory codes, standards, regulations, policy requirements, and design and construction information such as site-specific restrictions among others. The Output Specification also included a document outlining school-specific requirements in terms of strategy, vision, and design considerations and accommodation requirements. Concept design drawings (RIBA Stage B) were also prepared by the Technical Advisors to demonstrate the feasibility of the schemes within the budget and sites constraints. In terms of sustainability, the sustainability criteria included two main requirements:

- Projects should strive to achieve BREEAM for Schools’ ‘Excellent’ rating for new-build and ‘Very Good’ for refurbished buildings.
- Projects originally needed to meet Islington’s Sustainable Energy Planning Policy Framework, which require new developments to achieve 10% on-site renewable energy generation. This requirement was subsequently increased midway through the bidding process to 20% on-site renewable energy generation. The target was ambitious at the time and was pushing the boundary of what could be achieved for sustainable energy. According to the Project Architect, ‘Islington wanted to be the best in London’.

In addition to that, bidders were required to explore every opportunity for energy efficiency and carbon reduction above and beyond building regulation. Following PfS guidance, the Local Authority did not specify a particular renewable technology; instead bidders were required to demonstrate their ability to achieve the energy targets in a way that was least harmful and most beneficial. The sustainability requirements, particularly BREEAM and renewable energy generation targets, were made clear to bidders as early as the OJEU notice. The OJEU notice was seen by Local Authority actors as the most important stage to integrate sustainability as it allowed bidders enough time to develop their solutions in advance of actual tendering and improved the quality of solutions received.

To support their commitment to sustainability, Islington included sustainability as a criterion in their bid evaluation structure throughout the process. It featured as early as the Pre-Qualification Questionnaire (PQQ) scoring matrix where issues relating to sustainability appeared in three categories with a total weighting of 6%. More weighting was given to the technical aspects of sustainability in the Invitation to Participate in Dialogue (ITPD) bid evaluation process, with a total weighting of 14%. Albeit that, the weighting of sustainability on BSF bid evaluation criteria was not particularly satisfying to some parts of the Local Authority. According to LA Energy Manager, BSF bid evaluation failed to reflect Islington's strong corporate commitment to carbon reduction. The large number of issues involved in BSF bids resulted in sustainability being insufficiently weighted in bid evaluation. However, the LA Technical Advisor offered an alternative perspective arguing that the difference between bidders on the final stages of BSF bids could amount to as little as 1% or 2%. Therefore, while sustainability was not highly weighted, every single score was important and may have represented the difference between winning and losing the contract.

2. Clarity of the Sustainable Energy Requirement

The Invitation To Continue Dialogue (ITCD), accompanying Output Specification and contract documents, were sent to the three shortlisted bidders in August 2006. ProjectCo actors agreed that the output-based nature of the Output Specification provided the team with the flexibility to implement the best available technologies and encouraged innovation to take place. The challenging targets and objectives were seen to be one of the main drivers for sustainable energy on the project. However, two key issues were highlighted by ProjectCo actors as constraints to achieving an innovative sustainable energy outcome:

First, as shown in Box E3.1.1, weak definition of the sustainable energy requirement was seen by ProjectCo actors, particularly the ProjectCo WLC Director, Building Contractor's Operations Manager, Project Architect and M&E Engineer, to have left the requirement open to misinterpretation. The Output Specification was seen to closely follow standard PfS documentation and did not reflect the specificity of the project and the different school sites. ProjectCo actors also felt the large amount of information on the Output Specification resulted in duplication of targets and an unclear ranking of what was significantly important to the Local Authority. As the ProjectCo WLC Director commented:

> The Output Specification now puts so much information in them that it's difficult to see what really is important to the client that you're working with. It's hard to expand if someone downloads the Output Specification from an Output Specification website that exists, within a technical advisor's data base. 'I'll push some buttons and an Output Specification comes out!' and they put Islington on the front and they get issued. Perhaps I'm being a bit unfair there but a lot of it is generic, it's standard material. I think what we would prefer to see is much more project specific targets and measures that we get into discussion about early on and we challenge and the client challenges, because I think sometimes, some of the targets that make their way into the Output Specification would cost them money and would make it difficult. Actually the client, if you really challenge them, it's not really a priority but it's made its way into the document (ProjectCo WLC Director).

Second, achievability concerns raised by the change of the sustainable energy requirement to the 20% renewable energy target were seen by ProjectCo actors, particularly ProjectCo WLC Director and Building Contractor's Operations Manager, to be particularly challenging. The requirement originally submitted in the Outline Business Case (OBC) was 10% on-site renewable energy generation. However, Islington decided midway through the bidding process to increase the requirement to 20%. According to ProjectCo WLC Director, this change of requirement was introduced without adequate understanding of its impact on the original OBC and the affordability of the scheme. The targets had been pushed significantly forward, which, being in a competitive bidding environment, made it a considerable challenge for the team to meet those objectives. Indeed, the affordability of the scheme to the ProjectCo was questionable as a result of this change in the requirement.

3. Clarity of the Governing Framework

On HGS, ProjectCo actors agreed that the governing framework, in terms of regulation, standards and bid evaluation criteria, was made clear in the Output Specification. However, two key issues were highlighted by ProjectCo actors as constraints to achieving an innovative sustainable energy outcome in relation to the governing framework:

First, as shown in Box E3.1.2, while BREEAM was seen to push thinking into the broader realm of sustainability, however, ProjectCo actors unanimously argued that BREEAM could be mechanistic and easily swayed by site and local condition. According to the ProjectCo WLC Director, BREEAM also inhibited innovation because it encourages the use of materials from the Green Guide to Specification (BRE, 2009), restricting the use of other innovative materials and products.

Second, as shown in Box E3.1.2, ProjectCo actors, particularly the Project Architect and M&E Engineer, expressed concerns that the rigid design standards that the design needed to adhere to inhibited sustainability innovation. This was particularly the case when designing the east elevation of the building, which overlooks Highbury Grove, a busy emergency route. The noise levels permitted by Building Bulletin 93 (School Acoustics) meant that the east elevation of the building had to be sealed off completely, and all rooms located on this side of the building had to be mechanically ventilated; nearly 70% of the School area (Transform Schools, 2007). There was no scope within BB93 to allow for any openings in the elevation. This restricted the Design Team's ability to attempt the development of innovative solutions that could reduce noise levels whilst maintaining natural ventilation within these rooms.

In conclusion, Proposition 1 is not supported in this case study project. Weak definition of the sustainable energy requirement left the requirement open to misinterpretation. Achievability concerns raised by misalignment of the requirement and the project's budget also increased the pressure on ProjectCo actors. Deficiencies in the governing framework such as inability of BREEAM to promote innovation and the rigid design standards that projects needed to adhere to also discouraged further SEI.

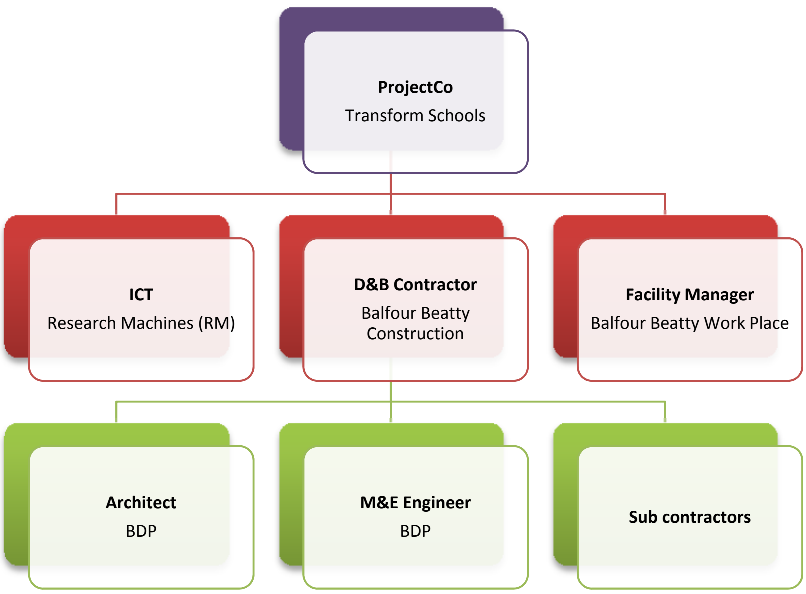
8.3.2 Proposition 2: Findings

The study's second proposition advances that SEI is supported by open communication and effective collaboration within the integrated ProjectCo, particularly among design, construction, and operation disciplines. This section will discuss the extent to which this conceptual proposition translated into experienced reality in supporting the implementation of SEI during the design development stages of HGS. The case study findings will be discussed under two headings: (1) Openness of communication (Box E3.2.1); and (2) Effectiveness of collaboration (Box E3.2.2).

1. Openness of Communication

During the competitive bidding process, bidders coordinated and managed their Consortium. In this case, Transform Schools (the ProjectCo) employed, coordinated, and managed Balfour Beatty Construction as the D&B Contractor. They also employed, coordinated, and managed the Facility Management Company, Balfour Beatty Work Place and the ICT provider, Research Machines (RM). The Building Contractor (Balfour Beatty Construction) then appointed, coordinated, and managed the Design Consultant, BDP. They also managed other consultants and members of the supply chain. The Consortium was managed by a Bid Management Team, which coordinated the Consortium and acted as their interface with public sector clients. Figure 8.2 illustrates the ProjectCo main contractual relationships.

Figure 8.2: The ProjectCo Main Contractual Relationships



Source: Developed for this research study

Open communication, as shown in Box E3.2.1, was supported by the Building Contractor appointing the Design Consultant, BDP, at the pre-qualification stage. This was seen to allow early discussions on constructability, affordability, and environmental performance. The Facility Manager, Balfour Beatty Workplace, was part of the Balfour Beatty Group of companies. While the Architect, consultants, and supply chain worked for the Building Contractor, the Facility Manager worked for the ProjectCo, so they were one step removed from the Design Team. A commercial Facility Management team was actively involved during the bidding phase and were an integral part of the team. However, Facility Management involvement was largely around maintainability with limited involvement in design development decisions. Indeed, FM's operational knowledge was seen to be largely underutilised in the development of SEI. The limited involvement of Facility Management was seen by the FM Operations Manager to be due to the limited funding allocated for this stage of the process. As the ProjectCo and its partners were working at their own risk, they were reluctant to allocate vast resources into their bidding team.

2. Effectiveness of Collaboration

As shown in Box E3.2.2, the ability of Balfour Beatty to offer an integrated service of design, construction, and operation was seen as an incentive for the team to improve the energy-efficient design of the School and operate it as energy efficiently as possible because ultimately they are responsible for the energy charge. The Architect, with an internal Sustainability Champion, played a fundamental role in leading the sustainability initiatives within the ProjectCo with a high level of expertise working on the project. However, relationships between the Architect and the Building Contractor were challenging at times. According to the Project Architect, the Contractors saw sustainability as a 'burden' and were not in a 'state of readiness' or ability to assess the design in the same way as the Design Team. The Architect had no access to cost information and poor exposure to the supply chain. Misalignment of objectives often resulted from the Architect's desire to achieve exceptional results for sustainability and the limited budget available to the Building Contractor. The Architect also found it difficult to ensure the Building Contractor's commitment to the Architect's sustainable 'Design Intent'. As the Project Architect explained:

> The paint finishing should be zero oxygen products. If I specify a green paint product and you need to put 5 coats on, Balfour Beatty will in a rush put Dulux on probably, full of toxic waste but they only need to put 2 coats on, so it is a struggle

> to get what we need ... insuring great 'design intent' is a struggle (Project Architect).

In fact, whilst bidding, the output-based nature of the requirement and the Building Contractor's desire to differentiate their bid allowed the Design Team to respond freely to the brief. However, once the bid had been won, the Architect was constrained by affordability considerations. Financial Close negotiations meant that many sustainability initiatives promised during the bid were somewhat compromised. Indeed, the Project Architect was increasingly frustrated in the BSF process allowing a maximum amount of freedom to architects in the bidding stages and then 'choking this off' as the project proceeded. The reasons for this was that the Architect reported to, and were employed by the Contractor, who in turn had a fixed price D&B contract with the ProjectCo SPV set up to control the project's risks. This limited the Architect's ability to continue to solve sustainable design problems in order to integrate further SEIs within the project.

In conclusion, Proposition 2 is not supported in the case study project. The case study findings suggest that the integrated design process espoused with the use of the PFI project delivery model has not actually translated into greater integration of the partners involved. It certainly did not result in the integration of operational facility managers into influencing design development decisions. Collaboration was also restricted by misalignment of objectives between the Architect and the Building Contractor. Under the Contractor-led D&B contract, the Architect felt restricted from pursuing further SEI in order to improve the energy performance of the building.

7.3.3 Proposition 3: Findings

The study's third proposition advances that SEI is supported by open communication and effective collaboration during BSF Local Authority-ProjectCo engagement processes. This section will discuss the extent to which this conceptual proposition translated into experienced reality in supporting the implementation of SEI during the design development stages of HGS. The case study findings will be discussed under two headings: (1) Openness of communication (F3.3.1); and (2) Effectiveness of collaboration (F3.3.2).

1. Openness of Communication

During the Competitive Dialogue process, communication between the different parts of the Local Authority and bidding consortia was organised by the Core Team. Main Communication with the ProjectCo was through their Bid Management Team. Both ProjectCo and Local Authority actors agreed that these single points of contact were effective in managing the interface between the Local Authority and bidders.

However, as shown in Box E3.3.1, several issues were raised by ProjectCo actors regarding the effectiveness of their communication with the Local Authority. The overall engagement process was deemed to be 'massively bureaucratic, cumbersome, time-consuming and frustrating' for both ProjectCo and Local Authority actors. The BSF process was seen to be 'prescriptive' and involved multiple issues and therefore pushed environmental sustainability and energy issues way down the priority list. While the competitive nature of the design process allowed the Local Authority to 'play one bid against the other', which highly improved the quality of the schemes, it had put ProjectCo actors under extreme pressure and increased their fear of giving away good ideas whilst bidding. The large amount of stakeholders involved in every meeting also made it difficult to have an honest discussion with bidders. According to LA Energy Manager, it was difficult to engage in honest discussions with bidders that were not compromised by the 'incredibly onerous' process that they were undertaking.

Despite that, the Local Authority managed to successfully realise their sustainability objectives. This was achieved by allocating a great amount of time for technical meetings with bidders to discuss their proposals in great detail. The Core Team built a Technical Team involving the key sustainability and energy expertise within the Local Authority. The Local Authority sustainability expertise in the form of the Sustainability Unit, Energy Management Unit, and Planning Department were actively involved. At the ITCD stage, the Technical Team also brought in specialists in various areas to work with bidders and review their sustainability solutions. Four-day-long meetings were exclusively held to discuss utilities, renewable technologies, and Payment Mechanisms. The LA Sustainability Unit was actively involved during this stage and several meetings were held with bidders to review their proposals. The role of the Sustainability Unit was fundamental as the 'Sustainability Champion', supporting the Core Team and acting as a source of sustainability knowledge across the Local Authority. The Energy Manager also held several meetings with the bidders concerning Energy Efficiency. Similarly, the engagement process involved many conversations with the Planning

Department, particularly around meeting the 20% on-site renewable energy target. This was seen by ProjectCo actors to provide as much clarity as possible to the Local Authority's sustainability objectives and aspirations. The multiple stages and gateways on the BSF process were also seen to allow ProjectCo actors to stop, evaluate, and continuously improve their design.

2. Effectiveness of Collaboration

Effective collaboration, as shown in Box E3.3.2, was largely supported by the close relationship between the Architect and the Local Authority, particularly the LA Sustainability Unit. Although the Design Team was appointed by the Building Contractor from an early stage and was one step removed from the Local Authority, the Architect was able to build close relationships with the Local Authority, particularly with the LA Sustainability Unit. The Sustainability Unit was championing sustainability and was an important source of sustainability knowledge to the ProjectCo Design Team. According to the Project Architect, Islington Council and its Sustainability Unit were in a complete 'state of readiness' to push forward a very sustainable agenda and were influential in securing the innovative outcome. Both the Architect, with an internal Sustainability Champion, and the LA Sustainability Unit took the challenge of making sure that the aim of a high quota of renewable energy technologies was implemented in the project. Indeed, the ProjectCo WLC Director argued that it was the individuals within the Local Authority who were pushing innovation, and not what was written in the 'Output Specification'. As he commented:

> From Islington's point of view I think what was obvious is that they have, as an authority, had a lot of very able and knowledgeable people in the broader Islington team, within planning and its environment and energy team. So I think, from my point of view, with Islington, it was the individual people's drive and interpretation and push on those matters that made Islington challenging and made us be innovative, not what was written in the documents (ProjectCo WLC Director).

Nevertheless, effective collaboration was restricted at times by the competitive nature of the design process. As design was running concurrently with bidding, the ProjectCo, and particularly the Building Contractor, was reluctant to invest too much time and resources into the design. The LA Energy Manager found it difficult to convince the Building Contractor to invest in CHP energy models whilst bidding, due to the costs involved. The Building Contractor was only willing to develop such models after they were appointed as Preferred Bidder, which, according to LA Energy Manager, was too late, as many design decisions were taken by then.

The ProjectCo was selected as the Preferred Bidder in May 2007. The period leading to Financial Close was seen to be difficult due to the complexity of the contract documents and commercial agreements leading to the establishment of the Local Education Partnership (LEP). Relationships between the Local Authority and the ProjectCo became difficult beyond the competitive stages. The Local Authority was no longer capable of controlling the information they received or the amount of dialogue that took place. Indeed, the BSF Preferred Bidder stage was seen to be problematic for sustainability outcomes. As the Preferred Bidder is often selected based on Stage D Outline Design, detailed design done afterwards may be compromised by affordability negotiations, resulting in sustainability being ‘squeezed’. Indeed, concerns were raised by LA Energy Manager regarding the difficulties of ensuring that sustainability promises made by ProjectCo actors during the bid would be delivered afterwards.

ProjectCo actors agreed that collaboration with the Local Authority could have been more effective. There was a perception among ProjectCo actors, particularly the Building Contractor, that continuous dialogue with the Local Authority might result in complicating the design process and lead to unrealistic sustainability demands. Indeed, the change of sustainable energy requirement from 10% to 20% of on-site renewable energy generation was particularly challenging to the ProjectCo. While Islington Council contributed additional funding to the project, the requirement was still deemed exhaustive. Mistrust and technical disputes regarding commercial issues dominated the relationship between the Local Authority and the Building Contractor for some time and the energy statement resulted in extensive debates throughout the process. According to the ProjectCo Assistant Bid Director, mistrust was generated by lack of understanding from parts of the Local Authority of budget constraints and the effect of such a change of requirement on the Contractor’s whole supply chain delivering the project. As he adds:

> I don’t think they ever understand the constraints around a project. We haven’t got £50 million to spend on photovoltaic panels. We’ve got X amount of money in total and some of that money can be spent on sustainable solutions. I think sometimes it’s bit of a blinkered view of the world from some people in those roles which make it difficult, good people and good intentions and know what they’re talking about when it comes to sustainability but sometimes beyond that segment they don’t quite grasp the wider context of the project we’re working on and

> which can be really difficult … they probably also didn't reflect on how a relatively simple change like that (*referring to the change from 10% to 20% of on-site renewable energy generation*), the knock-on impact of that across all our supply chain, all of our commercial discussions internally and all of those things that we need to do. I don't think there was recognition of that and obviously they're not interested in that, because they just want an answer! (ProjectCo Assistant Bid Director).

In conclusion, Proposition 3 was not supported in this case study project. Open Local Authority-ProjectCo communication was only enabled by the Local Authority's Core Team overcoming the inherent barriers to communication brought in by the nature of the BSF engagement process and facilitating communication between ProjectCo actors and their sustainability expertise. This provided bidders with as much clarity as possible to the Local Authority's sustainability objectives and aspirations. In addition, effective Local Authority-ProjectCo collaboration was supported by the Local Authority's competence and 'readiness to deliver' sustainability as well as the close Architect-Local Authority relationship. However, the study also identified that collaboration was restricted at times by the competitive nature of BSF engagement processes and misalignment of objectives between the ProjectCo and the Local Authority.

8.3.4 Proposition 4: Findings

The study's fourth proposition advances that SEI is supported by open communication and effective collaboration during BSF School-ProjectCo engagement processes. This section will discuss the extent to which this conceptual proposition translated into experienced reality in supporting the implementation of SEI during the design development stages of HGS. The case study findings will be discussed under two headings: (1) Openness of communication (Box E3.4.1), and (2) Effectiveness of collaboration (Box E3.4.2).

1. Openness of Communication

The ITCD documentations were issued to the three shortlisted bidders in August 2006 inviting bidders to respond to the Output Specification. Bidders' proposals were then tested against the Output Specification in a series of stages and gateways. The three bidders were also invited to engage in dialogue with the four schools involved in this phase of the BSF programme, including HGS. The purpose of the engagement process was for bidders' Design Teams to understand the School's aspirations and requirements. All parties involved in the School—student, management team, teaching and support staff and governors—contributed to the design process. The School was involved in milestone meetings throughout the ITCD phase. A series of six engagement meetings were organised by the Core Team, one meeting held every week for a period of six weeks. Attending the meetings would be the Core Team and their Design, Technical, and Education advisors (Cambridge Education). Balfour Beatty engagement team often included the Bid Director, Building Contractor, and Architect. The Architect presented their schemes and the School and Local Authority staff provided feedback. The focus of the meetings was on the School design but sustainability was also explored.

Nevertheless, as shown in Box E3.4.1, two issues were raised by ProjectCo actors regarding the effectiveness of their engagement with the School. First, engagement meetings were seen to be largely 'restricted'. They were also 'time-consuming' and 'exhausting' to School Engagement Teams that needed to attend massive amounts of meetings with the three bidders. Second, the opportunity to engage with the School on sustainability initiatives was also restricted by the Education Advisor (Cambridge Education) who was taking the lead in this matter. Bidders were instructed to focus on designing and constructing a low-energy building whilst the Education Advisor was responsible for developing the sustainability education aspects with the School.

2. Effectiveness of Collaboration

The School was increasingly interested in renewable technologies and their use as learning tools and part of the School Curriculum. The prospect for the School to become a leader for sustainability among other Islington schools and the wider community was also motivating for the School to demonstrate their commitment to carbon reduction. Therefore, the Design Team incorporated a small demonstration Wind Turbine for educational purposes. A Building Management System (BMS) was also included to help monitor, report, and reduce energy consumption. The data recorded by the BMS system would be displayed on the School's managed learning environment (intranet) so that students could see the impact of their activities on energy consumption, and compare their consumption with other schools. The Earth Tube intake vents were designed to be clearly visible within the School landscape to generate interest, awareness, and curiosity of pupils (see Image 8.3 below).

Image 8.3: HGS: Earth Tube Intake Vents
Courtesy of BBCap (2010)

However, as shown in Box E3.4.1, several issues were raised regarding the ability of ProjectCo actors to work with the School towards a common SEI goal. First, sustainability was not high on the School's agenda, with education being its ultimate priority. Second, due to the limited BSF budget, there was a constant effort to balance the School's educational requirement and the sustainability requirement. The significance of cost as a barrier to innovation and the need to balance the School's requirement and energy efficiency requirement was highlighted by the Assistant Bid Manager when he said:

> Costs, costs, that's the big one, always costs, so spending on energy efficiency versus spending on spacing the School, versus spending on quality of finishing the School, versus spending on landscaping. You're adding money into the pot for that, you're taking money away from somewhere else and it's the balance between getting that right but also providing what the School wants … ultimately the School needs to be energy-efficient but that's really secondary to delivering the educational requirements of the users. Really it's important but no School Head Teacher is going to tell you that he's really happy that his School is zero carbon but he can't teach because the spaces are rubbish! (ProjectCo Assistant Bid Manager).

Third, the School's requirement occasionally conflicted with the objective to reduce its overall CO_2 emissions. Initially, Local Authority planners insisted on removing all parking spaces on the Highbury Grove site in order to encourage cycling, walking, and ultimately reducing the School's carbon footprint. This was supported by the high accessibility of the School site, which has a Public Transport Accessibility Level of 5 (where 1 is the lowest and 6b is the highest), well-served by buses, underground, and rail services. However, the School Engagement Team was highly reluctant to reduce the number of parking spaces allocated on their site. Many teachers needed to drive to

School because they arrived early, left late, and carried valuable equipment on a daily basis. Female teachers also needed to feel safe coming to work. Eventually, after numerous discussions between the School and planners, a compromise was made by allocating a limited amount of parking spaces to the School. However, this restricted efforts to reduce the School's overall carbon footprint. Also, the School's anti-social behaviour issues and safety concerns restricted the development of some sustainable design features, such as open balconies and large atria to flood the School with natural light.

In conclusion, Proposition 4 is not supported on this case study project. School-ProjectCo communication was limited by the largely 'restricted', 'time-consuming' and 'exhausting' nature of the BSF engagement process. School-ProjectCo collaboration was also limited by the low priority to the School of sustainability issues and their lack of adequate technical knowledge about sustainability. Due to the limited BSF budget, there was a constant effort to balance the School's educational requirement with the sustainability requirement. The School's requirement also occasionally conflicted with the objective to reduce their overall CO_2 emissions.

8.3.5 Proposition 5: Findings

The study's fifth proposition advances that SEI is supported by clear, appropriate, and manageable allocation of the risks associated with the project's energy performance. This section will examine the extent to which this conceptual proposition translated into experienced reality in supporting the implementation of SEI during the design development stages of HGS. The case study findings will be discussed under three headings: (1) Clarity of risk allocation (Box E3.5.1); (2) Appropriateness of risk allocation (Box E3.5.2); and; (3) Manageability of risk allocation (Box E3.5.3).

1. Clarity of Risk Allocation

The energy strategy adopted on HGS was largely driven by the allocation of several energy-related risks to ProjectCo actors. Particularly important to ProjectCo actors were: *availability risk, energy consumption risk,* and *planning approval risk.* The availability risk, as it relates to the building environment, is that associated with the building environment not meeting agreed criteria and hence incurring availability penalties. As part of the PFI contract an 'Availability Clause' is linked to the Payment Mechanism in which a fine is levied for unavailability of any teaching spaces that exceed 28°C for more than 120 hr/yr (based on BB101 – Ventilation of School Buildings). *Energy consumption risk* is that associated with the building's operational energy consumption exceeding the agreed standard for maximum annual energy consumption in the contract. Planning approval risk refers to the energy solution adopted failing to meet a number of criteria including Islington's planning requirements of 20% on-site renewable energy generation. These three types of risk were seen as the major drivers for the innovative energy solution. The team also managed a number of other risks such as *BREEAM target risk*, the risk that the building fails to achieve the BREEAM 'Excellent' target and hence incurring penalties; *technical risk*, the risk that the solution adopted fails to meet technical criteria; and *capital cost risk*, the risk that the solution adopted is too expensive and hence rejected by the client.

As shown in Box E3.5.1, ProjectCo actors agreed that the risks associated with the energy strategy were made clear within the BSF contract and there is little controversy over their allocation.

2. Appropriateness of Risk Allocation

Contractually, meeting the Availability Clause was the responsibility of the ProjectCo SPV as part of the BSF PFI contract. Within the ProjectCo, the Building Contractor was responsible for the design and construction of the building meeting the energy targets for the initial period. The Facility Manager assumes both energy consumption and energy tariff risk for the first three years. Following this, energy consumption becomes the responsibility of the Facility Manager, while the Local Authority retains the risk on tariff.

As shown in Box E3.5.2, the risk allocation related to the energy strategy was generally considered fair and acceptable by ProjectCo actors. However, the Building Contractor taking the initial energy consumption risk was seen to be somewhat unfair by the ProjectCo WLC Director. The reason for this was explained by the difficulty to accurately predict the energy performance of the building based on calculations and energy models that could not account for all variables. Buildings also take a long time to bed down into their natural level of performance. In addition, there are many factors in the early operations of a building that might affect the building performance, which are not necessarily due to the contractor's lack of quality design or installation. According to ProjectCo WLC

Director, many of these issues are related to user behaviour, as opposed to the actual building itself. As he added:

> I mean maybe sometimes the contracts … the way the contracts work don't necessarily reflect buildings being a complex, almost organic entity, you can control them to a point but actually they still have a bit of a life of their own until you strip things down and understand things and analyse the performance detail monitoring and consumption monitoring and really use the building management systems to get information out of the building. So I think there's a lot more to be done in that area (ProjectCo WLC Director).

ProjectCo WLC Director also highlighted the conflicting environmental requirements that needed to be met under the BSF PFI contract, particularly the requirement for the building to meet the Availability Clause (teaching spaces not to exceed 28°C for more than 120 hr/yr), whilst maintaining agreed standards for maximum annual energy consumption and CO_2 reduction targets. The strategy adopted to meet those conflicting requirements was understandably to reduce the demand for energy through passive design principles, whilst increasing the efficiency of the supply as much as possible. However, ProjectCo WLC Director argued that the Availability Clause and the temperature tolerances forming part of its criteria are potentially detrimental to BSF energy efficiency and CO_2 reduction objectives. Excessive perceived availability risk may force contractors to install carbon-intensive technologies, such as HVAC, to ensure that teaching spaces will not exceed 28°C and safeguard their long-term investment in the project. This is particularly detrimental in situations where penalties for non-availability considerably exceed penalties for not meeting annual energy consumption targets.

3. Manageability of Risk Allocation

As shown in Box E3.5.3, the manageability of risk was an important criterion when developing the energy supply strategy. While the allocation of several types of risk to ProjectCo actors was considered manageable and, in fact, drove SEI, the allocation of others was considered excessive and difficult to manage within the BSF PFI environment. To develop the energy strategy, the Design Team had to take into consideration the conflicting requirements of meeting the Availability Clause on the PFI contract without jeopardising energy consumption and carbon emission targets. The

Design Team also had to deal with challenging site constraints, particularly around adjacency to emergency routes, which meant that 70% of the building needed to be mechanically ventilated (Transform School, 2007). The team evaluated several energy strategies in order to increase the likelihood of meeting the energy consumption targets while providing an internal environment comfortable to the School. The Design Team decided to pursue a strategy in which the demand for energy is minimised while the supply is as efficient as possible. The Design Team minimised energy demand by increasing the building's thermal mass and improving air leakage rates and U-values. The energy simulation models developed at the design phase were critical, not only to ensure the target was met, but also to minimise the risk for the Building Contractor. The energy supply solution developed by the Design Team was to adopt multiple technologies to provide flexibility and spread the energy risk across several technologies, energy providers, and users within the School. The School's low-energy design utilises high-end technologies (mini-Combined Heat and Power Plant, Ground Source Heat Pump, Earth Tubes, and mini-Wind Turbine) to offset and reduce carbon emissions and provide micro-generation. The integration of Earth Tubes into the design significantly reduced the energy demand from the heating and cooling plant. The energy solution underwent much scrutiny from the Building Contractor and ProjectCo Bid Management Team who were concerned about capital cost and affordability. The use of high-cost technologies with long payback periods, such as PVs was avoided to reduce capital cost risk. Adopting a combination of proven technologies was seen to minimise technical risks associated with the technology not performing as predicted. This was to satisfy investors and limit the risks carried by the ProjectCo.

Among the strategies initially considered for the sustainable energy supply strategy was District Heating Networks. Indeed, Islington's Energy Centre was interested in building essential energy supply agreements and Heating Networks linking schools with nearby housing estates. Several discussions took place between the ProjectCo, planners, and the Energy Centre to develop such a solution on the new BSF schools. However, the BSF process, the risks involved, and the inflexibility in the BSF contract restricted the development of such a proposal. First, off-take risk associated with understanding how much demand there is for the heat load was increased by the restricting BSF engagement process. It was difficult during the competitive dialogue stage to participate in discussions of sufficient detail with the 'local community' or providers to determine the feasibility and financial viability of delivering community schemes and energy networks. Moreover, construction risk associated with the uncertainty that the project would be delivered to the agreed budget was increased by the difficulty of linking the timing of network provision and School construction. This meant that if the system was to be adopted, it would be at the developer's risk, which was unsupported by the ProjectCo's shareholders and funders. It was also exacerbated by the inflexibility of the BSF contract to allow for off-site energy generation and the involvement of Energy Supply Companies (ESCOs) to install, finance, and deliver energy-efficient systems. Indeed, Islington's Energy Manager was equally disappointed in the inflexibility of BSF standard documentation, which limited the ability of the Local Authority to build District Heating Networks. As she commented:

> The government has obviously said, 'This is the world you are working in contractually.' And they're rigidly imposing it for the funding to come through. Although new-built sites are required by the government to achieve 60% carbon reduction target and go beyond building regulation, however, they are not offered the opportunity to think of new ways of achieving this target. It's like the government's trying to think it all through from the start without any flexibility to allow for these network opportunities (LA Energy Manager).

In conclusion, Proposition 5 was supported on this case study project. The risks associated with the project's energy performance were generally considered clear, appropriate, and manageable. In fact, the allocation of the risks associated with the project long-term energy performance to ProjectCo actors encouraged innovation to take place, in order to safeguard their long-term commitment to the project. However, excessive perceived innovation-related risks restricted further innovation. Perceived technical risk led to the adoption of a new combination of tried and tested technologies to minimise the risk that the technology would not perform as predicted. Perceived capital cost risk inhibited the adoption of high-cost technologies with long payback periods. The risks associated with the development of energy supply networks also restricted their adoption.

8.3.6 Proposition 6: Findings

The study's sixth proposition advances that SEI is supported by incentive-based payments linked to the project's energy performance. This section will examine the extent to which this conceptual proposition translated into experienced reality in supporting the implementation of SEI during the design development stages of HGS. The case study findings are shown in Box E3.6.1.

Islington adopted the standard BSF contract and Payment Mechanism in their contract with the ProjectCo. Energy efficiency is part of the efficiency in the FM service contract and is part of the unitary charge for the PFI contract. In terms of energy, the standard BSF mechanism dictates that the Facility Manager operating the School takes the risk on both energy consumption and tariff for the first three years. During this period the energy performance of the building is monitored by the Facility Manager. At the end of this period energy consumption is benchmarked and the Facility Manager subsequently takes the risk on consumption while the Local Authority takes the risk on tariff. This re-benchmarking procedure is scheduled to take place every three years. The ProjectCo compares its prices for energy to the price of equivalent service provision in the market. Subsequently, the corresponding part of the Unitary Payment is adjusted according to a pre-agreed formula. The ProjectCo can reap the benefit of any cost savings as a result of introducing energy-saving systems and strategies within the utility period before energy consumption is re-benchmarked.

ProjectCo actors, as shown in Box E3.6.1, unanimously highlighted the limited capacity of the BSF PFI contract in providing adequate incentive to the ProjectCo for continuous improvement in energy efficiency or installation of low-carbon technologies. The continuous benchmarking of energy consumption in the BSF contract offered limited reward for the ProjectCo from improving energy efficiency mid-contract. ProjectCo actors argued that the lack of incentives in the Payment Mechanism to improve energy consumption mid-contract is a barrier to achieving exceptional results for energy efficiency. While over-achieving could potentially create an environment for innovation and continuous improvement, the BSF PFI contract was seen to offer the incentive to achieve exactly the bare minimum.

The Local Authority actors, as shown in Box E3.6.1, also highlighted the deficiencies in the BSF contract in terms of ensuring the ProjectCo's continuous commitment to renewable technologies. The standard BSF contractual documents proved to be an obstacle when Islington tried to secure the LEP's long-term commitment to renewable technologies. While BSF standard documents provided the Local Authority with the power to demand the installation of renewable technologies as part of their requirement, BSF standard documents do not commit the LEP into using the technologies during operation, if other options are considered to be cheaper. Having identified this weakness in the BSF contract, Islington's Core Team in collaboration with their technical advisors tried to introduce changes to the Payment Mechanism that would tie the LEP into using the renewable technologies in operation. However, getting these changes approved by Partnerships for Schools (PfS), the governmental body responsible for the delivery of the BSF programme, was a significant challenge. The whole ethos of PfS is to have standardised documentation that the market is aware of and comfortable with. Therefore, Islington's desire to pursue alternative contractual terms was seen to be 'creating a two-tier system' and was highly opposed by PfS. While PfS does allow local authorities the freedom to write their requirement, they are restricted in their ability to redraft bespoke contractual clauses. For example, local authorities can specify schools to achieve 'Excellent' BREEAM rating, above PfS's accepted only 'Very Good' requirement, provided it is achievable within their allocated budget. It is only when local authorities try to introduce additional penalties or changes to the Payment Mechanism that PfS intervenes. This is because PfS is seen to strongly assume the role of the 'Keeper' of the standard documentation within BSF. The LEP commitment to using the renewable technology during operation was only strengthened by the planning condition attached to the School's energy performance. The planning condition requires the energy performance of the School to be evaluated after two years of operation. If the target of 20% carbon reduction is not met, then the LEP is required to put in place new mechanisms to achieve it. According to LA BSF Project Manager, it is a 'stick' that can be used to make sure the target is achieved.

In conclusion, Proposition 6 is not supported in this case study. The continuous benchmarking of energy consumption scheduled to take place as part of the contract offers limited reward for the ProjectCo from improving energy efficiency mid-contract. BSF contractual documents were also seen to be deficient in securing the LEP's commitment to using the renewable technology in the long-term, if cheaper options became available.

8.4 Summary

The aim of this research study is to develop an understanding of the capacity of the PFI project delivery model to support the implementation of SEI on BSF new-build school buildings. This Chapter examined the extent to which six conceptual propositions have translated into experienced reality in supporting the implementation of SEI during the design development stages of HGS. The main case study findings are as follows:

1. Proposition 1 was not supported. Weak definition of the sustainable energy requirement and performance standards left the requirement open to misinterpretation and somewhat compromised. Achievability concerns raised by misalignment of the requirement with the project's budget also increased the pressure on ProjectCo actors. Deficiencies in the

governing framework such as inability of BREEAM to promote innovation and the rigid design standards that projects needed to adhere to also restricted further SEI.

2. Proposition 2 was not supported. The case study findings suggest that the integrated design process espoused with the use of the BSF PFI delivery model has not actually translated into greater integration of the partners involved. It certainly did not result in the integration of operational facility managers into influencing design development decisions. Collaboration was also restricted by misalignment of objectives between the Architect and the Building Contractor. Under the Contractor-led D&B contract, the Architect felt restricted from pursuing further SEI in order to improve the energy performance of the building.

3. Proposition 3 was not supported. Open Local Authority-ProjectCo communication was restricted by the complexity of the BSF engagement process. Open communication was only achieved due to the Local Authority's Core Team overcoming the inherent barriers to communication brought in by the nature of the BSF engagement process and facilitating communication between ProjectCo actors and their sustainability expertise. This provided bidders with as much clarity as possible to the Local Authority's sustainability objectives and aspirations. Effective Local Authority-ProjectCo collaboration was supported by the Local Authority's competence and 'readiness to deliver' sustainability as well as the close Architect-Local Authority relationship. However, the study also identified that collaboration was restricted at times by the competitive nature of BSF engagement processes and the misalignment of objectives between the ProjectCo and the Local Authority.

4. Proposition 4 was not supported. Open School-ProjectCo communication was limited by the largely 'restricted', 'time-consuming' and 'exhausting' nature of the BSF engagement process. Joint School-ProjectCo collaboration was also limited by the low priority of sustainability issues to the School and their lack of adequate technical knowledge about sustainability. In addition, due to the limited BSF budget, there was a constant effort to balance the School's educational requirement with the sustainability requirement. The School's requirement also occasionally conflicted with the objective to reduce its overall CO_2 emissions.

5. Proposition 5 was supported. The risks associated with the energy strategy were generally considered clear, appropriate, and manageable. In fact, the allocation of the risks associated

with the project long-term energy performance to ProjectCo actors have encouraged innovation to take place, in order to safeguard the ProjectCo long-term commitment to the project. However, excessive perceived innovation-related risks restricted further innovation. Perceived technical risk led to the adoption of a new combination of tried and tested technologies to minimise the risk that the technology would not perform as predicted. Perceived capital cost risk inhibited the adoption of high-cost technologies with long payback periods. The risks associated with the development of energy supply networks also restricted their adoption.

6. Proposition 6 was not supported. The continuous benchmarking of energy consumption as part of the PFI contract offers limited reward for the ProjectCo from improving energy efficiency mid-contract. BSF contractual documents were also seen to be deficient in securing the LEP’s commitment to using the renewable technology in the long-term, if cheaper options become available.

Chapter 9: Case Study 4

Image 9.1: BWS: Aerial View showing the new School (centre) and the old School (bottom left)
Courtesy of NCC (2009)

This Chapter presents the findings from Big Wood School (BWS) case study. The Chapter is divided into four sections. The first section provides a brief introduction to the project, the Sustainable Energy Innovation (SEI) implemented, and the project's sustainable energy design features. The second section outlines the key sources of data. The third section explores the case study findings based on the six propositions developed in Chapter 4. The fourth section offers a concluding summary of the case study's findings.

9.1 Introduction

BWS is one of three schools[9] in the first phase of Nottingham's £222m Building Schools for the Future (BSF) programme. It is a £19.5m new-built Business and Enterprise College for 750 pupils aged 11–16. The School is located within a relatively deprived community, albeit one which has a pleasant urban character and bounded by residential properties to its east and west. The vision for the new School was to be transformational in the way it works across the community, so that every member of the community has the opportunity to be healthy, stay safe, make a positive contribution, and achieve economic well-being.

The new BWS development was part of Nottingham's BSF 'Sample' schemes. It therefore was one of three school projects the Council went to market with when procuring their BSF programme and was designed as part of a competitive dialogue process. Nottingham City Council's OJEU notice was published in November 2006 and the Preferred Bidder was selected in January 2008. The Council's Preferred Bidder, Inspired Spaces, was a Consortium that comprised Carillion/RBoS/HSBC (Equity Providers), Carillion Construction (Building Contractor), Capita Symonds (Design Consultant), Carillion FM (Facility Management), and Ramesys (ICT). Financial Close was reached in June 2008 creating Nottingham's Local Education Partnership. Construction on-site started in June 2008. The School was partially opened in September 2009, while the second phase of the project opened in November 2010.

Image 9.2: BWS: Outdoor Area
Courtesy of NCC (2010)

BWS was selected as a case study for its innovative energy supply solution. The School has an Energy Centre housing a biodiesel Combined Heat and Power (CHP) plant, the first to be implemented in a school in Britain. The CHP plant provides heating and electricity. It also substantially offsets the demand for grid energy, leading to dramatic carbon savings. The School is also designed to

[9] The other two schools were Hadden Park High School, for refurbishment, and the new-build of Oak Field School and Specialist Sports College.

‘Excellent’ BREEAM rating and achieved 60% reduction in CO_2 emissions against Part L 2002 Building Regulation[10]. The School’s key sustainable energy design features are outlined in Figure 9.1.

Figure 9.1: BWS Sustainable Energy Design Features

Energy Efficiency:

The new facility is designed and built to reduce energy demand relative to Part L 2006 standards through use of passive design features such as:

- **Lighting:** Natural lighting was introduced deeply into the building by large light wells. The size of the classroom windows is adequately sized to allow the School to be well lit.
- **Ventilation:** Natural ventilation was introduced deeply into the building by air chimneys and large roof lights. Classroom windows are openable and their size meant the School is well ventilated. Mechanical vents in classrooms are adjustable to draw more air in when needed.

Renewable Energy:

The renewable energy target for 20% was met through the following means:

- **Biodiesel CHP Plant:** The School has an Energy Centre housing a biodiesel Combined Heat and Power (CHP) plant, the first to be implemented in a school in Britain. The CHP plant provides 70% of the School’s heating and electricity demand. It also substantially offsets the demand for grid energy, leading to dramatic carbon savings. The CHP uses local pure rapeseed oil produced and supplied from north Nottingham. The School also has the ability to sell electricity to the grid and to create revenue through green certificates.
- **Demonstration Wind Turbine and Photovoltaic Panels (PVs):** A demonstration wind turbine and a small amount of PVs are also installed for educational purposes.

The School design achieved 60% reduction in CO_2 emissions (against Part L 2002 Building Regulation)

Source: Developed for this research study

9.2 Case study Participants

Data collection for this case study involved 12 semi-structured interviews with key project stakeholders. Table 9.1 lists the actors that took part in the research study. It describes each interviewee in terms of his/her respective organisational team and the interviewee’s position within the team (please refer to Table 5.4 in Chapter 5 for a description of how stakeholders were selected

[10] BWS was shortlisted in the ‘Best Design for a New School’ category in the National 2009 Excellence in BSF awards. The LEP (‘Inspired Spaces’ Nottingham Ltd) was the winner of the ‘Local Education Partnership of the Year’ category in the National 2009 Excellence in BSF Awards.

to be included in the study, including a description of their role and responsibilities). It also outlines the title used to refer to the interviewee within the case study findings.

Table 9.1: BWS Case Study Participants

Team	Interviewee	Title used to refer to interviewee within the case study findings	Ref.
The Local Authority: Nottingham City Council (NCC)			
BSF Management Team	Design Manager	LA Design Manager	L1
	Technical Advisor	LA Technical Advisor	L2
	Sustainability Advisor	LA Sustainability Advisor	L3
Planning Department	Principal Planning Officer	LA Planning Officer	L4
The ProjectCo: Inspired Spaces			
Bid Management Team	Bid Director	ProjectCo Bid Director	P1
Building Contractor (Carillion)	Education Director	Building Contractor's Education Director	P2
	Operations Manager	Building Contractor's Operations Manager	P3
Architect (Capita Symonds)	Project Architect	Project Architect	P4
M&E Engineer (Capita Symonds)	Project Engineer	M&E Project Engineer	P5
Energy Consultant (Low C)	Project Manager	ProjectCo Energy Consultant	P6
Facility Manager (Carillion)	Contract Manager	FM Contract Manager	P7
The School: BWS			
School Engagement Team	Head Teacher	School Head Teacher	S1

Source: Developed for this research study

9.3 Case Study Findings

This section will present findings from BWS case study. The case study findings are divided into six subsections according to the six research propositions developed in Chapter 4. Table E4 in Appendix E reviews the key findings for each proposition. The table summarises emergent issues for each conceptual construct (defined in Table 5.6 of Chapter 5), synthesised from the 12 case study interviews, and demonstrates the theory underlying the empirical findings. Effort was made to tie the Box related to each theoretical construct clearly to the text. Each proposition subsection is also illustrated with quotes from the case study interviewees.

9.3.1 Proposition 1: Findings

The study's first proposition advances that SEI is supported by the greater clarity of the sustainable energy requirement and governing framework on the BSF PFI Output Specification. This section will discuss the extent to which this conceptual proposition translated into experienced reality in supporting the implementation of SEI during the design development stages of BWS. The case study findings will be presented under three headings: (1) The development of the sustainable energy requirement; (2) Clarity of the sustainable energy requirement (Box E4.1.1); and (3) Clarity of the governing framework (Box E4.1.2).

1. The Development of the Sustainable Energy Requirement

The management of Nottingham City Council BSF programme was dedicated to a Core BSF Project Management Team (referred to as the Core Team in the remainder of this Chapter). The team included a Project Director, a Project Manager, a Design Manager, an Education Manager, and an ICT Manager. The view behind this multidisciplinary approach was to build a 'lean team', allowing members to represent multiple objectives and work collaboratively as a group. The team was also supported by a technical and sustainability advisory team (Faithful & Gould) and a Client Design Advisor.

BSF funding was seen as an opportunity for Nottingham City Council to completely rebuild its school's estate. Due to their age, existing school buildings in Nottingham struggled to cope with the needs of 21st Century learning, strongly affecting their ability to improve education for their children. In contrast to the 1970s' and 1980s' 'piecemeal' patterns of development, BSF offered the prospect of realising the Local Authority's transformational learning aspirations. The Local Authority's aspiration was for new and remodelled buildings to provide flexible environments which could adapt easily to future models of Curriculum and School organisation. The new schools were to be in excellent condition, light and airy with natural ventilation, and better accessible to pupils with disabilities and to the wider community.

Sustainability was also a fundamental feature of the new schools' design to ensure that new schools contributed to the City Council's ambition to become a Carbon-neutral Council by 2016 and a Carbon-neutral City by 2100. Indeed, Nottingham City Council has a long-standing corporate commitment to sustainability and is a leader of sustainability among local authorities. At the time the BSF programme was developed, Nottingham City Council was signing other local authorities to the 'Nottingham Declaration'. Launched in October 2000 in Nottingham, the Declaration had been signed by 300 English Councils by 2010 and many other local organisations, such as Fire & Rescue Services, National Park Authorities, Primary Care Trusts, and Waste Disposal Authorities. By signing the Nottingham Declaration councils and their partners pledge to systematically examine the causes of climate change and to prepare their community for its impacts. Therefore, the BSF programme was seen to offer a huge potential for rolling out good practice and a great delivery vehicle for the infrastructure to build a sustainable community.

At the time Nottingham City Council was introduced to BSF, the Authority did not have a dedicated Sustainability Unit, or an Energy Management Unit. However, the commitment to sustainability cascaded all the way through from senior councillors to members of the Core Team. The pursuit of a sustainable solution was fundamentally driven by the Core Team and particularly the LA Design Manager. The LA Design Manager had a real passion for sustainability and a clear vision of what could be achieved through BSF. Supported by the technical, design, and sustainability advisors, the Design Manager ensured that sustainability formed an important part of the Local Authority's vision and requirement. Nottingham City Council Planning Department also took the lead on driving a 20% on-site renewable energy generation on all school sites. The School community was also invited to take part in discussions about the sustainability requirement, but these discussions were superseded by more pressing consultations on educational strategies.

Image 9.3: BWS: Facade
Courtesy of NCC (2010)

The Output Specification closely followed the standard documentation format provided by PfS. In terms of sustainability, the requirement was principally governed by the City Council policy on sustainability and carbon-reduction targets. Initially there were some difficulties in the drafting of the sustainability requirement within the Output Specification. This was due to the newness of the programme for Nottingham as a 'Wave 2' Local Authority and the lack of experience and knowledge about the implementation of sustainability within the BSF context. In addition, while the Local Authority's aspiration was to future-proof the new-build element by increasing the specifications above and beyond current building regulations, this was difficult to specify due to the limited funds available, which only allowed compliance to current Part L building regulation. The limited budget available for sustainability was frustrating to the LA Design Manager as he argued:

> The limited BSF budget might lead to the delivery of a project that was virtually obsolete from day one! (LA Design Manager).

Ultimately, the sustainability criteria included two main requirements:

- Projects should strive to achieve BREEAM for Schools' 'Excellent' rating for new-build and 'Very Good' for refurbished buildings.
- Schemes needed to meet the Nottingham Sustainable Energy Planning policy Framework, which requires new developments to achieve 20% on-site renewable energy generation as a condition for achieving planning permission.

Moreover, an additional requirement was introduced during the Preferred Bidder stage. In April 2008, the DCSF funding for energy efficiency was introduced and awarded to the project. It provided an additional £50/m^2 investment to achieve a 60% reduction in carbon emission based on a baseline of standards set in the Part L 2002 building regulation. This requirement translated into an operational carbon target of no more than 27kg CO_2/m^2/yr for core School hours. This operational obligation was placed on the Building Contractor responsible for designing and building the scheme and aligned their obligation more closely to what has been delivered. The target was a punitive legal caveat to ensure the facility remains low-carbon into the future.

As part of the information handed out to potential bidders, the sustainability advisors also prepared a Sustainability Guide outlining Nottingham City Council's aspirations for improved thermal performance, improved natural ventilation, and natural lighting. It also emphasised that BSF schemes had to align with the Council's current carbon reduction targets as stated in the 'Nottingham Declaration'. The sustainability guide also highlighted to potential bidders the Local Authorities' interest in creating outside technologies for alternative energy generation such as

Combined Heat and Power (CHP) plants and District Heating Networks linking Schools with adjoining housing developments.

To strengthen their commitment to design quality, the Local Authority indicated in their requirement documents that 'Design Quality' would be rewarded in the bid evaluation criteria by forming 30% of the final evaluation score. The objective was to signal to potential bidders the Local Authority's view of Design as a 'key indicator'. However, due to the large number of matters involved, issues specifically related to energy had a small percentage in the bid evaluation criteria, and formed only 3% of the evaluation criteria.

2. Clarity of the Sustainable Energy Requirement

The ITCD, accompanying Output Specifications and contract documents were sent to the three shortlisted bidders in May 2007. ProjectCo actors, as shown in Box E4.1.1, unanimously agreed that the sustainable energy requirement was made clear in the Output Specification. The output-based nature of the requirement also provided the team with considerable flexibility to pursue innovative solutions to energy efficiency. The output-based nature of the requirement allowed sustainability to be interpreted differently and, therefore, the authority benefited from bidders proposing alternative strategies to achieve it. As the ProjectCo Bid Director commented:

> We started with a blank piece of paper, unlike other projects when contractors build what architects designed or what clients specifically asked for (ProjectCo Bid Director).

The requirement was also seen to provide an incentive to innovate, particularly the challenging government carbon target of 27kg $CO_2/m^2/yr$, coupled with the additional DCSF funding. The requirement was seen by ProjectCo actors as largely innovative and the first to be placed, as an operational obligation, on a Building Contractor. The Local Authority's clear preference to specific technologies, such as CHP, also reduced the risk that suggesting undesirable technologies could jeopardise the bid.

3. Clarity of the Governing Framework

On BWS, ProjectCo actors agreed that the governing framework, in terms of regulation, standards, and bid evaluation criteria, was made clear in the Output Specification. However, two concerns were raised by ProjectCo actors in relation to the governing framework. First, as shown in Box E4.1.2, ProjectCo actors acknowledged that achieving BREEAM 'Excellent' rating was a key criterion. However, ProjectCo actors, particularly the Bid Manager, Project Architect, M&E Engineer, and Energy Consultant, questioned the ability of BREEAM to support the delivery of an energy-efficient school. According to the ProjectCo Energy Consultant, BREEAM 'Excellent' does not ensure that the School will perform as energy-efficient as possible during operation, as credits can be scored for issues unrelated to the building. It also alters the way Contractors develop their strategies. In fact, the ProjectCo Energy Consultant pointed out that some contractors would install Biomass Boilers in order to achieve BREEAM credits, while in reality the Contractor would install a small Biomass Boiler but also a large Gas Boiler and would run the School largely on gas. Moreover, BREEAM would not protect the Local Authority from future taxations around energy consumption such as the eminent Carbon Reduction Commitment (CRC) coming into effect in 2012. As the ProjectCo Energy Consultant pointed out:

> If a measure is, for any client, a certificate on the wall with the 'Excellent' BREEAM rating and 20% renewables achieved on-site and compliant with regulations then that can be achieved. But if they believe that it will actually deliver an operational low carbon project and actually protect them from the risks of the CRC and other taxation around energy and the appliance of energy, when the actual metering is the actual build, then I'm sorry, that's not the case (ProjectCo Energy Consultant).

Second, as shown in Box E4.1.2, the low weighting given to sustainability and energy issues within BSF bid evaluation was seen not to motivate the ProjectCo to achieve exceptional results for energy efficiency. The ProjectCo Bid Director argued that it was not the energy performance of the designs that differentiated bids, but it was the innovations proposed within the bid that ultimately captured the Local Authority's attention. Indeed, innovation was seen as a 'sales' strategy to secure the bid. As he said:

> You knew if you get the best ever energy result down here you might make a tiny, tiny, tiny percentage difference to your mark. But what you did know was that if

> you say 'Ta, da! I've got a great solution', then everybody starts thinking 'Oh, that's good.' If there's energy and something innovative people start to, in their mind, kind of promote you (ProjectCo Bid Manager).

In conclusion, Proposition 1 is supported on this case study project. The requirement was successful in providing the ProjectCo with the freedom to innovate, through the output-based nature of the requirement, and the incentive to innovate, through the challenging 27kg $CO_2/m^2/yr$ carbon target, coupled with the additional DCSF funding. The Local Authority's clear preference to CHP technologies also reduced the risk that suggesting undesirable technologies could jeopardise bid. However, while the governing framework was considered clear, the study identified that unfavourable governing frameworks, such as the inability of BREEAM to promote energy efficiency and the low weighting given to sustainability in bid evaluation were seen to dampen incentives for SEI.

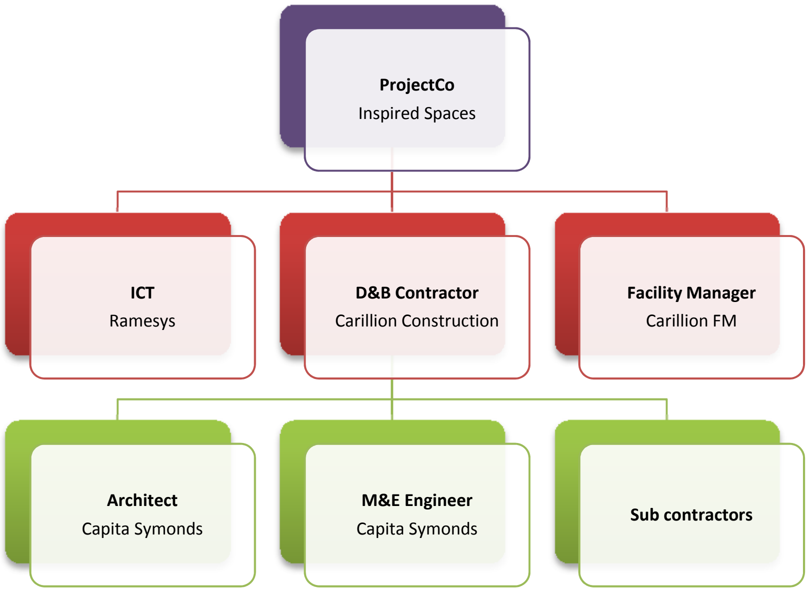
9.3.2 Proposition 2: Findings

The study's second proposition advances that SEI is supported by open communication and effective collaboration within the integrated ProjectCo, particularly among design, construction, and operation disciplines. This section will discuss the extent to which this conceptual proposition translated into experienced reality in supporting the implementation of SEI during the design development stages of BWS. The case study findings will be discussed under two headings: (1) Openness of communication (Box E4.2.1); and (2) Effectiveness of collaboration (Box E4.2.2).

1. Openness of Communication

During the competitive bidding process, bidders coordinated and managed their Consortium. In this case, Inspired Spaces, the ProjectCo, coordinated and managed Carillion Construction as the D&B Contractor. They also coordinated the Facility Management Company, Carillion FM. The Building Contractor, Carillion Construction then appointed, coordinated, and managed the Design Consultant, Capita Symonds, and other consultants and members of the supply chain. The Consortium was managed by a Bid Management Team, which coordinated the Consortium and acted as their interface with public sector clients. Figure 9.2 illustrates the ProjectCo main contractual relationships.

Figure 9.2: The ProjectCo Main Contractual Relationships



Source: Developed for this research study

Open communication, as shown in Box E4.2.1, was supported by the Building Contractor appointing the Architect during the pre-qualification stage. Thus, discussions on constructability took place early in the design process. The Facility Management provider was part of the Carillion Group of companies. While the Architect, consultants, and supply chain worked for the Building Contractor, Facility Management worked for the ProjectCo, so they were one step removed from the Design Team. The Facility Management team was not involved during the bidding phase and their involvement only commenced following Financial Close. The limited participation of Facility Management was explained by the FM Contract Manager to be due to two main issues. First, as the ProjectCo was working at risk whilst bidding, they were reluctant to over-commit resources to this stage of the process. Therefore, there was no allocation of fees for an operational Facility Manager to be part of the bid team. Second, it was difficult to appoint an operational Facility Manager on bid teams without compromising his/her original job. As the FM Contract Manager explains:

> It's one thing having an FM background then go and work on the bid team but once you've been on bid team you get brought into the bid ethos. You lose your ability to be proactive and negative because you're part of a routine so you go with the bid flow and you forget a lot of your operation experience. As your principal who's got a day job as an FM ops to a bid team is handy but it should be a very, very short secondment so they can go back to their day job. You can't have someone continuously running as FM within a bid team because it's not being an FM, they start being bid team (FM Contract Manager).

The limited involvement of facility managers during the early design development process introduced several challenges post-bidding. An operational Facility Management team was invited following Financial Close to participate in M&E design, interface building with the Architect, and to offer M&E solutions and lessons learnt. However, according to the FM Contract Manager, the Design Team seemed to be centred on what they wanted and did not listen to Facility Management concerns. The Facility Management Team was not engaged to assist in any of the solution implemented. This resulted in the Design Team producing elements that Facility Management could not maintain. For example, the heating system within the school building was not controllable by the BMS System due to ineffective design of interfaces. The BMS under-floor heating cabinets installed are difficult to access on a regular basis. The lighting in the atria can only be changed using a cherry picker brought into the facility by a lorry, thus undermining most CO_2 savings gained from installing energy-efficient lighting in the first place.

2. Effectiveness of Collaboration

The ability of Carillion to offer the integrated service of design, construction, and operation was seen as an incentive to achieve the best energy solution possible. ProjectCo actors unanimously agreed that the long-term commitment of Carillion through the facility management contract motivated the team to improve the energy-efficient design of the School because ultimately they were responsible for the facility's energy consumption during operation. This incentive was further strengthened by the introduction of the government's 27kg $CO_2/m^2/yr$ target and placing this obligation on the Building Contractor. According to the Building Contractor's Operations Manager, as the Building Contractor was legally liable and financially responsible for any rectification needed for the building to meet this target, they were incentivised to take the operational energy performance of the building into consideration.

However, the relationship between the Architect and the Building Contractor was challenging. The Project Architects felt they were working under a difficult position within BSF because they were pushed by the needs of the bids and the personalities within the Local Authority and the Contractor. According to the Project Architect, the Design Team had different agendas from the Contractor because their agenda was not necessarily cost. However, although the Architects were capable of managing within cost, the Contractor did not share cost information with the Architects and did not engage with them on that level. The Project Architect also believed they were driven to 'tokenistic' and 'Eco-Bling' strategies by the Contractor. As part of their submission, Carillion allocated a sustainability 'gift' of £50K for each school. The fund was to allow schools to decide on how to improve the sustainability of their building. According to the Project Architect, the fund was effective as a 'sales pitch', but it lent itself to 'add-on' and 'tokenistic' strategies. The fund was too small, given the £20m cost of the new facility, and was later used to increase the insulation of the envelope and roof. However, the Design Team achieved considerably less than what they hoped to achieve. The Project Architect maintained that energy technologies are often selected based on how strongly they 'symbolise' energy efficiency, rather than being selected based on actual calculations of their energy performance. According to the Project Architect, a more energy-efficient approach would have been to maximise passive design principals such as adopting super-insulation strategies, but they were driven to designing a building that 'leaked energy' but had a 'cleanish' energy source by the Contractor. The Design Team also had fewer opportunities for having the quantity of consultants and experts that could be outside BSF. This was due to the limited time available during the design process, but also to the Contractor's unwillingness to allocate funds for the extra cost of consultants. As the Building Contractor was responsible for all costs and risks whilst bidding, they were reluctant to allocate too much resource into this stage of the process.

The relationship between the Architect and the Contractor became more difficult as the project progressed to Preferred Bidder stage. During this phase, negotiations continued with the Local Authority, albeit with only one bidder. The Preferred Bidder stage took five months in which the Contractor developed their 'Contractor Proposal (CP)' documents. During this stage, new personnel got involved from the Contractor-side, with no history of what was promised during the bid. The new members of the Contractor's team fought for tried and tested solutions, rather than what was promised during the bid. As promises made during the bid were not contractually binding unless they formed part of the Financial Close documents, many sustainability initiatives were compromised. According to the Project Architect:

> Some of the initiatives that were sold on the design-efficiency side fell by the wayside post-bidding (Project Architect).

In conclusion, Proposition 2 is not supported on this case study project. This was due to the lack of integration of Facility Management into influencing design decisions and misalignment of interests between the Architect and Contractor. However, the study identified that the ProjectCo composition, particularly the integration of design, construction, and operation services by Carillion PLC, as well as placing operational obligations on the Building Contractor, incentivised the Building Contractor to consider the operational energy performance of the building as a priority.

9.3.3 Proposition 3: Findings

The study's third proposition advances that SEI is supported by open communication and effective collaboration during BSF Local Authority-ProjectCo engagement processes. This section will discuss the extent to which this conceptual proposition translated into experienced reality in supporting the implementation of SEI during the design development stages of BWS. The case study findings will be discussed under two headings: (1) Openness of communication (Box E4.3.1); and (2) Effectiveness of collaboration (Box E4.3.2).

1. Openness of Communication

Communication between the different parts of the Local Authority and bidding consortia was organised by the Local Authority's Core Team. Main Communication with the ProjectCo was through their Bid Management Team. As shown in Box E4.3.1, both ProjectCo and Local Authority actors agreed that these single points of contact were effective in managing the interface between the Local Authority and bidders.

However, as shown in Box E4.3.1, several issues were raised by both ProjectCo and Local Authority actors regarding the effectiveness of their communication. First, the engagement process was seen to be an intense period with many other elements discussed, hence, sustainability was not particularly high on the discussion agenda. Second, because the Design Team was working under the Building Contractor from an early stage, it thus felt initially distanced from being able to build a close relationship with the ultimate clients, being the Local Authority and School. Third, the magnitude of stakeholders involved during the engagement process highly complicated the design process. According to the Project Architect, the ability to design a low-energy building was distorted by the 'Tug and Pull' of different stakeholders' opinions. As the Project Architect explains:

> I think it's very difficult to describe what it's like to be in a BSF bid to those that haven't experienced it. I think you have to be within a BSF bid to know what it's like. You get tugged in lots of different directions and you are held at the whim of a comment. A comment that could come from any facet of stakeholder that is involved and can carry an unimaginable effect once you go behind closed doors. So the smallest comment from a minor stakeholder can have a huge effect for everyone because nobody knows during the bid whose voice carries the most weight. So it's an incredibly difficult process to go through in that sense. Somebody may say something about PVs and all of a sudden PVs are the thing that we've got to have and you can't do without. The following week it's not mentioned and it goes away. The balance in itself, should you just be designing it, would be difficult. So you wouldn't normally have a CHP next to a biomass with too much PVs, with a multitude of technologies, you just wouldn't do it. But because you get so many people saying 'I saw this on that School', all of a sudden, right! We've got to have that! So it was difficult to try and guide the design through that type of arena with that audience that you're facing every other week (Project Architect).

However, despite the restrictive BSF process, the Core Team managed during the ITCD stage to set aside two consultation sessions to meet with bidders and discuss their approach to sustainability. The Core Team and particularly the LA Design Manager and Sustainability Advisor were, therefore, able to challenge bidders' sustainability proposals. This communication was seen by ProjectCo actors to be essential in clarifying the Local Authority's commitment to sustainability, given other project requirements and constraints. Sustainability was seen to be 'embedded' in the Local Authority's procurement terms and was made clear to ProjectCo actors throughout the BSF process. The Core Team ensured that the strategies developed are directly linked to the Authority's corporate agenda around sustainability. Key individuals within the Core Team, such as the Design Manager, also played the central role of the 'Sustainability Champion' promoting sustainability across the Local Authority and pushing its implementation on the BSF programme.

2. Effectiveness of Collaboration

Effective collaboration, as shown in Box E4.3.2, was largely supported by the committed Core Team. Indeed, the role of the Local Authority Core Team was fundamental in driving the innovative energy-efficient design. Commitment to sustainability cascaded throughout the Local Authority, from senior officers in the Council down to the Core Team. ProjectCo actors agreed that innovation was facilitated by the 'receptive, supportive, and encouraging' Core Team. The team was committed to sustainability, was knowledgeable enough to engage in a 'two-way' dialogue about its delivery, and was willing to accept new ideas. The Core Team ensured throughout the dialogue process that the strategies developed were directly linked to meeting their corporate agenda around sustainability. As the ProjectCo Energy Consultant pointed out:

> The authority was an open door, and Carillion recognised the fact that there was an open door in terms of going to them to have this conversation. Nottingham was driven by the real desire to deliver something which works and which actually gives a carbon saving which is with reference to the actual building as it runs. Not as it fits in terms of regulations (ProjectCo Energy Consultant).

ProjectCo Engagement Team used the dialogue process to develop deeper understanding of what was important for the Local Authority. The team identified Nottingham's ambition to become Europe's most sustainable City by 2020 and attempted to develop strategies to contribute to meeting this target. The Core Team members were seen to be open, straightforward, and consistent. The team was also seen to be clear about their sustainability requirements and determined to pursue a specific sustainable energy objective, one that defines and demands innovation. Sustainability as a requirement was made clear in the Local Authority's corporate plan, their BSF procurement of terms, and through all the development process. They also challenged every aspect of sustainability proposed by the ProjectCo. The importance of the Local Authority's ability to engage in debate about sustainability was highlighted by the Contractor's Education Director when he said:

> Every authority that we engage with will talk about sustainability. The interesting thing is that Nottingham meant it and the more the authority drives it and has it spelt out in a document, the better solution they'll get. And it will force bidding organisations to go the extra mile for them. Which is exactly what Nottingham did. Because you could sit and talk to Nottingham and you actually had a high quality

> debate about sustainability and what they wanted to see and how we could deliver it. And how we could test it. And when it's embedded you can do that. When it's not embedded, it's a bit of lip service. We're doing what we think on sustainability. What happens is we are a sustainability 'Champion', rather than if it is sustainability from a Local Authority's point of view. So that's a massive difference between local authorities. They all mean it. I'm sure they all mean it but some have an absolute focus on doing it (Contractor Education Director).

The ProjectCo was selected as the preferred bidder in January 2008. Carillion's CHP approach was seen to be much superior to other bidders' proposals. While Carillion was seen to embrace the Local Authority's Requirement, other bidders were seen to pursue more compliant-based solutions with 20% being met by biomass. However, the period leading to Financial Close was seen to be difficult, particularly for the design development process. As Financial Close was signed on RIBA Stage F design drawings, the limited time between Preferred Bidder and Financial Close meant that design needed to move rapidly from Stage D to F. Consequently an important design stage, Stage E, was lost on BSF. Affordability negotiations during this stage also meant that some of the sustainability initiatives promised during the bid were compromised. Indeed, concerns were raised by the LA Sustainability Advisor regarding the difficulties of ensuring that sustainability promises made by ProjectCo actors during the bid were actually delivered afterwards.

In conclusion, Proposition 3 is not supported on this case study project. Local Authority-ProjectCo communication was largely restricted by the nature of BSF engagement process. In fact, effective communication was only overcome by the Local Authority's Core Team ensuring sufficient communication between ProjectCo actors and their sustainability expertise. This communication was seen to be essential in clarifying the Local Authority's commitment to sustainability, given other project requirements and constraints. Joint Local Authority-ProjectCo collaboration towards SEI was also supported by the Local Authority's competence and 'readiness to deliver' sustainability.

9.3.4 Proposition 4: Findings

The study's fourth proposition advances that SEI is supported by open communication and effective collaboration during BSF School-ProjectCo engagement processes. This section will discuss the extent to which this conceptual proposition translated into experienced reality in supporting the implementation of SEI during the design development stages of BWS. The case study findings will be discussed under two headings: (1) Openness of communication (Box E4.4.1), and (2) Effectiveness of collaboration (Box E4.4.2).

1. Openness of Communication

The ITCD, accompanying Output Specification and contract documents were sent to the three shortlisted bidders in May 2007. Bidders were invited to respond to the Output Specification and their proposals were then tested against the requirements in a series of stages and gateways. The three bidders were also invited to engage in dialogue with the four schools involved in this phase of the BSF programme, including BWS. The engagement process was organised to allow bidders' Design Teams to understand the School's aspirations and requirements. Meetings took place between the Bidders' Design Teams and School's Engagement Team specifically around the designs of the Sample Schemes. The personnel included in the School's Engagement Team were the Head Teacher, Deputy Head Teacher, and School Caretaker. Several Design Quality Indicators (DQIs) sessions were held during this stage to judge the design proposals. The engagement process took a period of nine months, divided into two stages, with six meetings in each stage. The meetings were held every two weeks and lasted for two to three hours. Meetings were attended by Carillion's engagement team which included the Bid Director, and representatives from the Building Contractor, and Architect.

Communication with the School was greatly supported by a committed School Engagement Team. The School was fortunate in that their Caretaker was a former builder and was able to engage effectively with bidders. The Deputy Head Teacher was also in charge of the project and was committed to innovation. The Head Teacher was an 'inspirational' character who saw BSF as a 'once-in-a-lifetime' opportunity not only for her pupils but for the whole community.

However, as shown in Box E4.4.1, several issues were raised by both ProjectCo and School actors regarding the effectiveness of their engagement. First, the engagement process was seen by both ProjectCo and School actors to be very 'formal', 'cold' and very 'difficult'. It was an intense period with extremely tightened timescales. Engagement meetings involved two or three School representatives but many representatives from the Local Authority. The Education Manager, Design Manager, and Client Design Advisor attended at all times. The focus of the discussions was mainly on master planning and building layout. Sustainability was not particularly high on the discussion agenda. The School was briefed to be impartial and nonpartisan, and therefore was unable to talk freely with bidders. According to the School Head Teacher, the School needed to talk in 'coded language' throughout the engagement process, which was difficult. As the School Head Teacher explains:

> Because you'd be sitting in a meeting, they'd be showing you something and I'd be thinking which one had the 'such and such' that I quite liked. But you can't say that. You can't say I don't like it. So it's all, you know. It was madness. Talking in coded language I think the whole time. And I found that very difficult (School Head Teacher).

Second, the School Head Teacher also felt there was lack of recognition of the pressures BSF puts on a School. The School Engagement Team was still expected to carry out its responsibilities of teaching and managing the School, while taking part in BSF meetings, which was exhausting. As the Head Teacher explains:

> But I mean we have many meetings … non-stop meetings. The difference being that all the builders think it's so easy. They've got nothing else to do but do building. I've actually got to run a School. So it's difficult (School Head teacher).

Third, relationships between the Design Team and the School were also restricted. The Design Team was working under the Building Contractor from an early stage and therefore their direct communication with the School was fairly constrained. However, communication changed as the project moved to the preferred bidder stage from being 'generic' and equal for all the bidders to being 'specific'. The School was able to talk freely and target their comments specifically to their winning design. The design therefore changed considerably during preferred bidder stage. This resulted in an intense four-month period so as to achieve planning permission before Financial Close.

2. Effectiveness of Collaboration

The School interest in sustainability as a learning resource was seen as the main driver for effective collaboration. The School saw the pursuit of a sustainable solution as an opportunity to enrich the School Curriculum and for the children to learn about renewable technologies. The School was interested in incorporating a demonstration Wind Turbine and a small amount of PVs for Educational purposes. A Building Management System (BMS) was also integrated by which the School's energy consumption and production would be monitored and displayed in the entrance area. By showcasing the CHP technology, schoolchildren will have a better understanding of where energy comes from and the importance of leading low-carbon lifestyles. It will also be used as a learning resource across the School Curriculum.

However, as shown in Box E4.4.2, several issues were raised by ProjectCo Actors regarding the effectiveness of their collaboration with the School. First, sustainability was not high on the School's agenda. The School priority was fundamentally transforming the learning experience for their pupils with limited knowledge to contribute to the discussion about sustainability. The School Head Teacher similarly highlighted this concern when she explained:

> I'm the Head Teacher. I'm not a Builder. But yet I'm expected to think about buildings. I don't know about buildings. But I know what works with kids. And it's about transforming learning. Not transforming buildings. That's my role, transforming people not transforming buildings (School Head Teacher).

Second, the Project Architect also highlighted the conflict between the School's educational requirement and the sustainability requirement. The Design Team needed to reach a delicate balance between achieving outstanding results for energy-efficient design, whilst delivering transformational environments internally and externally to the School. As the Project Architect commented:

> Because it's pointless having a low-energy or zero-carbon School and they can't use it as a School (Project Architect).

Third, due to the nature of the PFI management contract, the School had limited responsibility over the energy performance of their building. The School was to be managed by a Facility Management team who would oversee all aspects of the building, including its energy consumption. According to the Head Teacher, although the merit of this arrangement was that it releases School Heads from the burden of managing the School premises and allows them to concentrate on teaching matters, it significantly reduces their control over their building. The School Head teacher found that difficult to accept. As the Head Teacher explains:

> This is the problem with BSF, because although that's my School, I actually don't have a clue as to what's going on up there in those terms at the moment *(referring to energy consumption)*, because it is provided by the facilities management team, which isn't mine. And I find that the hardest thing to be. I don't feel I have control over the School. And I hate it. But I know that they tell you 'That is wonderful because you don't have to worry about it.' But I don't feel that yet. And they say, 'Think of it like being in a hotel room.' Well, I tell you what: if I was in this hotel I'd move out! (School Head Teacher).

In conclusion, Proposition 4 is not supported in this case study project. Open School-ProjectCo communication was somewhat constrained by the controlled, restricted, time-consuming, and formal nature of the engagement process. Joint School-ProjectCo collaboration towards sustainability was constrained by the low importance of the sustainability issue to the School, with educational requirement being their ultimate priority. The School also lacked technical knowledge about sustainability in order to be able to contribute effectively in discussions about its implementation. Conflict occasionally arose between the School's transformational learning aspiration and energy-conscious design. In addition, under the PFI contract, the School lacked control over their building, including its energy performance.

9.3.5 Proposition 5: Findings

The study's fifth proposition advances that the implementation of SEI is supported by clear, appropriate, and manageable allocation of the risks associated with the project's energy performance. This section will examine the extent to which this conceptual proposition translated into experienced reality in supporting the implementation of SEI during the design development stages of BWS. The case study findings will be discussed under three headings: (1) Clarity of risk allocation (Box E4.5.1); (2) Appropriateness of risk allocation (Box E4.5.2); and (3) Manageability of risk allocation (Box E4.5.3).

1. Clarity of Risk Allocation

The energy strategy adopted on BWS was largely driven by the allocation of several energy-related risks to ProjectCo actors. Particularly important were: *carbon target risk*, *planning approval risk* and *availability risk*. The government's carbon target of 27kg $CO_2/m^2/yr$ was a contractually binding operational obligation included in the Payment Mechanism and was a condition attached to the project being awarded £50/m² additional funding. The funding was to introduce energy efficiency and renewable energy measures to achieve the challenging target of 60% reduction in carbon emission (compared to a School being constructed to the energy efficiency standards set out in the 2002 Part L Building Regulation). *Planning approval risk* refers to the energy solution adopted failing to meet a number of criteria, including Nottingham's planning requirements of 20% on-site renewable energy generation. The *availability risk*, as it relates to the building environment, pertains to the building environment not meeting agreed criteria and thus incurring availability penalties. As part of the PFI contract an 'Availability Clause' is linked to the Payment Mechanism in which a fine is levied for unavailability of any teaching spaces that exceed 28°C for more than 120 hr/yr (based on BB101 – Ventilation of School Buildings).These three types of risk were seen as the major drivers for the innovative biodiesel CHP energy solution. The team also managed a number of other design-related risks such as BREEAM *target risk*, the risk that the building fails to achieve the BREEAM 'Excellent' target and hence incurring penalties; *technical risk*, the risk that the solution adopted fails to meet technical criteria; and *capital cost risk*, the risk that the solution adopted is too expensive and hence rejected by the client.

As shown in Box E4.5.1, ProjectCo actors agreed that the high-level risks related to energy were made clear within the BSF contract and there is little controversy over their allocation.

2. Appropriateness of Risk Allocation

Contractually, meeting the Availability Clause was the responsibility of the ProjectCo SPV as part of the BSF PFI contract. In addition, as part of the contractual agreement tied to the DCSF low-carbon funding, the Building Contractor had to commit to achieving a benchmark operational carbon emission ratio of 27kg $CO_2/m^2/yr$ during defined core hours. The Building Contractor was awarded the extra funding of £50/m² to deliver the carbon target and, therefore, was expected to take that risk. The Facility Manager assumes both energy consumption and energy tariff risk for the first three years. Following this, energy consumption becomes the responsibility of the Facility Manager, while the Local Authority retains the risk on tariff.

The general perception among ProjectCo actors was that there was little controversy over the allocation of risk pertaining to the energy strategy. The Building Contractor agreed that the carbon target risk was acceptable and fairly allocated. However, as shown in Box E4.5.2, the Building Contractor's Education Director questioned the target itself and felt the 27kg $CO_2/m^2/yr$ target was an onerous target that is difficult to completely mitigate. The risk was minimised by adopting passive design principals as well as greening the energy supply through the biodiesel CHP plant. However, it was a difficult risk to close out. The success of the mitigation strategy will only be clear when the building is operational for a period of time.

3. Manageability of Risk Allocation

As shown in Box E4.5.3, the manageability of the energy-related risks allocated to ProjectCo actors was an important criterion when developing the innovative supply solution. Achieving the government's carbon target of 27kg $CO_2/m^2/yr$ was seen by ProjectCo actors as particularly important to developing the innovative biodiesel CHP solution. The Bid Director identified from an early stage that the Architect and the M&E engineers lacked sufficient knowledge on renewable energy technologies to be able to advise the team on meeting the CO_2 target. Consequently, the Bid Director appointed an Energy Consultant to help develop an energy strategy that could meet the CO_2 target. The Energy Consultant undertook extensive research within Carillion's existing PFI Schools in order to devise a robust strategy to deliver the carbon target.

Image 9.4: BWS: Large Storage Tank
Courtesy of NCC (2009)

The strategy consequently developed was based on operational information received from Carillion's PFI Schools which suggested that electricity consumption is responsible for the largest proportion of CO_2 emission in Schools, as opposed to heating demand. Therefore, an energy supply solution that involved on-site electricity generation was seen to be the optimum to deliver the carbon target. The Energy Consultant and ProjectCo Bid Director decided to adopt a biodiesel CHP plant, the first to be implemented on a School in the UK. According to the ProjectCo Bid Director, pursuing the innovative biodiesel CHP solution needed courage because CHP plants are not widely used in school buildings. It was also technically challenging because the extra heat output needed to be managed. The CHP plant was, therefore, designed to a size in which the heat output could be used efficiently, with the only summer load being the daily demand for domestic hot water. A large storage tank was also essential to flatten out loads (see Image 9.4 above). The Energy Consultant was also able to source a local supply of rapeseed oil to fuel the CHP plant five miles away in North Nottingham, thus improving the sustainability performance of the complete solution.

However, the CHP solution faced a great deal of internal resistance, criticism, and scrutiny from other members of the ProjectCo, who were sceptical about putting a biodiesel CHP plant in a school building, the sourcing of fuel, and the connection to the grid. The solution was seen as a high-risk strategy that could jeopardise the team's proposal. During this stage, the role of the Bid Director was fundamental in overcoming resistance to innovation and providing the leadership needed to implement the biodiesel CHP solution. The innovation process was explicitly coordinated by the Bid Director who saw the CHP solution as a viable solution to meet the CO_2 target, as well as a 'winning strategy' to differentiate their bid. The crucial role of the Bid Director was highlighted by the Energy Consultant when he commented:

> I think that the Carillion team, as it was at the time, with Austin at the helm, I think he was open to the idea of sticking his neck out a little bit and allowing us to do something different … what I find is that it's not comparing Carillion with Balfour Beatty, with Laing O'Rourke or whatever, it's actually much more team-specific. We find teams in Carillion who are much more resistant to doing that. It just so happened that with Austin at the helm, he cleared a lot of the obstacles out of the way for us. And he was really driven by the fact that he wanted the investment in our time in the project to actually deliver. He said to us 'It's got to be one of our top priorities. It's got to be one of the top selling points we put in our bid.' And if we can make sure we're on track with that then he'll clear obstacles out of our way and he did that. Austin was there, he was absolutely behind us. But, if you'd have heard some of the comments that we've had in terms of 'You'll never make the CHP work on a School, this fuel where do you get it? If you can't get this fuel, then forget it! You will never get a grid connection to allow your CHP to export to the grid!' All these obstacles put in our way internally from the team, it was great to have Austin there saying 'Well, you know we're going to win this project, it's going to go off the back of energy and carbon, so just do it! Get on with it! Drive a railway through those concerns, that's what it is!' But you can almost see there, how these concerns that are presented along the way stop so much innovation

> going on in the industry. You've got to have somebody there at the helm who actually understands the reasons behind what you're doing and what the benefit of that will be. Because it could win a project and it proved to do so, so in the end Austin's gamble paid off! (ProjectCo Energy Consultant).

Nevertheless, other considerations were necessary to implement the innovative CHP solution. According to the ProjectCo Bid Director, the innovation did not necessarily involve high 'risk-taking'. In the case of the biodiesel CHP, although it can be considered an innovation in UK school buildings, it is not a new technology and the CHP plant was purchased from a well-known German manufacturer. The robustness and proven track record of the technology was, therefore, equally important to satisfy investors and limit the long-term risk carried by the ProjectCo. In addition, capital cost risk was managed by avoiding high-cost technologies with long payback periods. The long-term commitment of the ProjectCo to the project did not justify investment in high-cost technologies because payback periods were equally important. Indeed, affordability was seen as a major consideration by the ProjectCo. The building had a limited amount of PVs for educational purposes but they were deemed too expensive to install a sufficient amount that could contribute to the building energy performance.

In conclusion, Proposition 5 is supported in this case study project. Indeed, the risks associated with the energy strategy were generally considered clear, appropriate, and manageable. The innovation itself entailed risks that needed to be managed. Technical risk associated with innovation was managed by appointing an Energy Consultant to help develop an energy strategy that could meet the CO_2 target. The role of the Bid Director was crucial in overcoming internal resistance to innovation and providing the leadership needed to reach the innovative outcome. The innovation itself did not necessarily involve high 'risk-taking' and the CHP plant was purchased from Germany from a well-known manufacturer.

9.3.6 Proposition 6: Findings

The study's sixth proposition advances that SEI is supported by incentive-based payments linked to the project's energy performance. This section will examine the extent to which this conceptual proposition translated into experienced reality in supporting the implementation of SEI during the design development stages of BWS. The case study findings are shown in Box E4.6.1.

Nottingham City Council adopted the standard BSF contract and Payment Mechanism in their contract with the ProjectCo. Energy efficiency is part of the efficiency in the FM service contract and is part of the unitary charge for the PFI contract. The Building Contractor was also awarded the extra funding of £50/m^2 to deliver the carbon target of 27kg CO_2/m^2/yr during core hours. The contract dictates that should the facility emit more CO_2 during these core hours, the PFI Consortium is required to pay the first 10% increase in fuel costs, and 50% of any increase thereafter. Should the building be more efficient in operation the Consortium reaps the full benefit of the first 10% under target and 50% of any additional savings.

ProjectCo actors, as shown in Box E4.6.1, unanimously agreed that the operational carbon target and the incentive-based Payment Mechanism linked to achieving the target encouraged the ProjectCo to achieve exceptional results for sustainable energy. It also encouraged the team to ensure that the facility will remain energy-efficient during operation by introducing new technologies should they become available in the market. The incentive-based Payment Mechanism allows the benefits of improving the energy performance of the facility to be shared among ProjectCo and Local Authority actors, thus encouraging SEI mid-contract. However, the ProjectCo Bid Director and the ProjectCo Energy Consultant also argued that the effectiveness of such a mechanism depends on how closely it will be monitored and enforced. According to the ProjectCo Energy Consultant, it is important for this mechanism to work to be monitored by an expert. It also depends on how considerable the penalty is for operating above the cap of 27kg CO_2/m^2/yr. According to the ProjectCo Energy Consultant, if the penalty exceeds the financial gain by going to a more carbon-intensive fuel, then there is a big enough 'stick'.

In conclusion, Proposition 6 is supported on this case study project. The incentives linked to achieving the carbon target encouraged ProjectCo actors to achieve exceptional results for sustainable energy. It may also encourage ProjectCo actors to ensure that the facility remains energy-efficient by introducing innovative energy-saving technologies should they become available in the market during operation. The presence of such incentives allowed the benefits of improvements to be shared among ProjectCo and Local Authority actors, thus supporting SEI efforts.

9.4 Summary

The aim of this research study is to develop an understanding of the capacity of the PFI project delivery model to support the implementation of SEI on BSF new-build school buildings. This Chapter discussed the extent to which six conceptual propositions have translated into experienced reality in supporting the implementation of SEI during the design development stages of BWS. The main case study findings are as follows:

1. Proposition 1 was supported. The requirement was successful in providing the ProjectCo with the freedom to innovate, through the output-based nature of the requirement, and the incentive to innovate, through the challenging 27kg $CO_2/m^2/yr$ carbon target, coupled with the additional DCSF funding. However, the study also identified that unfavourable governing framework, such as the inability of BREEAM to promote energy efficiency and the low weighting given to sustainability in bid evaluation offered limited incentives for SEI.

2. Proposition 2 was not supported. This was due to the lack of integration of Facility Management into influencing design decisions and misalignment of objectives between the Architect and Building Contractor. However, the study identified that the ProjectCo composition and placing operational energy obligations on the Building Contractor incentivised the Building Contractor to consider the operational energy performance of the building as a priority, aligning their interests with those of the Facility Manager towards SEI.

3. Proposition 3 was not supported. Local Authority-ProjectCo communication was restricted by the BSF engagement process and the inherent BSF barriers to communication were only overcome by the Local authority's Core Team ensuring sufficient communication between ProjectCo actors and their sustainability expertise. This communication was seen to be essential in clarifying the Local Authority's commitment to sustainability, given other project requirements and constraints. Effective collaboration towards SEI was driven by the Local Authority's competence and 'readiness to deliver' sustainability.

4. Proposition 4 was not supported. School-ProjectCo Communication was somewhat constrained by the controlled, restricted, time-consuming, and formal nature of the engagement process. School-ProjectCo collaboration towards sustainability was weakened by the low importance of the sustainability issue to the School, with educational

requirement being their ultimate priority. The School also lacked technical knowledge about sustainability in order to be able to contribute effectively in discussions about its implementation. Occasional conflict arose between the School's transformational learning aspiration and energy-conscious design. Under the PFI contract, the School also lacked control over their building, including its energy performance.

5. Proposition 5 was supported. The risks associated with the energy strategy were generally considered clear, appropriate, and manageable. In fact, the risk associated with meeting the government's carbon target of 27kg $CO_2/m^2/yr$ was seen as the main driver for the CHP innovation. The innovation itself entailed risks that needed to be managed. Technical risk was managed by appointing an Energy Consultant to help develop an energy strategy that could meet the CO_2 target. The role of the Bid Director was crucial in overcoming internal resistance to innovation and providing the leadership needed to reach the innovative outcome. The innovation itself did not necessarily involve high 'risk-taking' and the CHP plant was purchased from Germany from a well-known manufacturer.

6. Proposition 6 was supported. The operational carbon target and the incentives linked to achieving the target encouraged ProjectCo actors to achieve exceptional results for sustainable energy. It may also encourage ProjectCo actors to ensure that the building remains energy-efficient by introducing innovative energy-saving technologies should they become available in the market during operation. The presence of such incentives allowed the benefits of improvements to be shared among ProjectCo and Local Authority actors, thus supporting SEI efforts.

Chapter 10 - Discussion

10.1 Introduction

This Chapter examines the capacity of the PFI project delivery model to support the implementation of Sustainable Energy Innovation (SEI) in six parts, defined by the research propositions developed in Chapter 4. First it considers the issues that arise from the client requirement, in the form of the BSF Output Specification. Second, it explores the issues that relate to multidisciplinary communication and collaboration, particularly the relationship between design, construction and operation. Third, it examines the issues that emerge from Client-Producer communication and collaboration, in the form of Local Authority-ProjectCo engagement processes. Fourth, it discusses the issues that stem from User-Producer communication and collaboration, in the form of School-ProjectCo engagement processes. Fifth, it identifies the issues that relate to contractual incentives, particularly BSF PFI risk allocation. Sixth, it considers the issues that arise from the BSF PFI Payment Mechanism. The seventh section provides a summary of the main case study findings.

10.2 Discussion of Findings

This section presents the research findings. The presentation of the research findings is divided into six sections according to the six research propositions. Each section will examine the extent to which the conceptual proposition has translated into experienced reality in supporting the implementation of SEI during the design development stages of the multiple case studies. Table 10.1 below summarises the status of the six research propositions within each of the four case study projects and the replication outcome. In addition, Appendix F includes six tables summarising the key findings for each proposition. The tables review the evidence for each conceptual construct (defined in Table 5.6 of Chapter 5) and demonstrate the theory underlying the empirical support. Efforts were made to tie those tables clearly to the text in this discussion Chapter.

Table 10.1: Status of the Six Research Propositions within each of the Four Case Study Projects and the Replication Outcome

Conceptual Proposition	Status				Replication Outcome
	Case Study 1	Case Study 2	Case Study 3	Case Study 4	
P1: Clarity of Requirement	X	X	X	√	X
P2: Multidisciplinary Communication and Collaboration	X	X	X	X	X
P3: Client-Producer Communication and Collaboration	X	X	X	X	X
P4: User-Producer Communication and Collaboration	X	X	X	X	X
P5: Risk Allocation	√	X	√	√	√
P6: Reward Sharing Mechanisms	X	X	X	√	X

Note: √= supported, X= not supported
Source: Developed for this research study

It should be noted that the research findings have limitations presented by the chosen research methodology. The findings concern only four BSF PFI school projects. Therefore, as Rintala (2004) argues, the findings stemming from this type of methodology are merely hypotheses that need to be confirmed or rejected. In order to be representative of all BSF PFI school projects, the research findings need to be tested using quantitative research.

10.2.1 Proposition 1: Findings

The study's first proposition advances that SEI is supported by the greater clarity of the sustainable energy requirement and governing framework on the BSF PFI Output Specification. The multiple case study findings, as outlined in Table F1 in Appendix F, however, identify that Proposition 1 is not supported. Two key findings can be drawn to explain why the proposition is not realised across the case study projects. The multiple case study findings are presented below under two headings: (1) Clarity of the sustainable energy requirement; and (2) Clarity of the governing framework.

1. Clarity of the Sustainable Energy Requirement

The multiple case study findings, as outlined in Box F1.1 and Box F1.2, indicate that greater clarity of the sustainable energy requirement was influenced by two issues: (i) Specificity of the sustainable energy requirement, and (ii) Achievability of the sustainable energy requirement. The case study findings will be discussed below.

i. Specificity of the Sustainable Energy Requirement

It is often cited that output-based requirements are effective drivers for innovation (HM Treasury, 1999; Heavisides and Price, 2001; Leiringer, 2006). Output-based specification is said to provide private actors with greater "design freedom" to translate the client requirement (Leiringer, 2006) and releases their innovative capacity (Heavisides and Price, 2001). The multiple case study findings, as outlined in Box F1.1, identify that the flexibility and scope for innovation provided by the output-based nature of the sustainable energy requirement was acknowledged on SVC (Case Study 2), HGS (Case Study 3), and BWS (Case Study 4). ProjectCo actors involved on the three case studies agreed that the output-based nature of the requirement allowed the teams' considerable flexibility to suggest innovative solutions to meet the energy requirement. The local authorities also benefited from bidders coming with alternative solutions to achieve it.

However, the case study findings also suggest that the espoused benefits of the output-based nature of the requirement were negated at times by the limited 'specificity' of the requirement, which left sustainability open to interpretation and somewhat compromised. Limited specificity resulted from the local authorities' provision of a general sustainable energy requirement that did not reflect the sensitivity of its particular context. This was observed on BEC (Case Study 1) and HGS (Case Study 3). On BEC (Case Study 1), the Local Authority's provision of non-specific energy performance standards, such as in the form of the general requirement to 'reduce energy consumption', increased uncertainty and the potential for misinterpretation of the requirement. The requirement also lacked site-specific targets for carbon reduction or on-site renewable energy generation, as Bristol planning policy did not require it at the time. The Local Authority actors were seen as 'very broad-concept people' and unable to articulate their requirement. ProjectCo actors found it difficult to translate the Local Authority's higher level sustainability objectives into physical solutions to be incorporated into the building. The output-based nature of the requirement was seen to increase the risk that suggesting high-cost renewable energy technologies may result in the ProjectCo failing to win the bid. On HGS (Case Study 3), the Local Authority's dependence on BSF standard documentation led to a generic requirement that did not reflect the specificity of the schools' sites. The clarity of the requirement was also restricted by the large amount of information included in the Output Specification. This resulted in targets being duplicated and a lack of a clear hierarchy of the Local Authority's priorities.

This case study finding, therefore, suggests that the espoused benefits of the output-based nature of the sustainable energy requirement may be restricted at times by its limited specificity, leaving room for uncertainty and leading to misinterpretation of the requirement by ProjectCo actors. Indeed, the case study findings indicate that output-based requirements may fail to represent the context-sensitive nature of sustainability. In the case of SEI, the newness of the sustainable energy requirements to firms necessitate adequate specificity in order to ensure appropriate definition and, thus, greater understanding of the requirement by ProjectCo actors.

ii. Achievability of the Sustainable Energy Requirement

The multiple case study findings, as outlined in Box F1.2, indicate that 'achievability' of the sustainability requirement is an important dimension of its clarity and can be characterised by its sensitivity to existing technological and financial constraints. Achievability concerns pertaining to the sustainable energy requirement were found to increase the pressure on ProjectCo actors and restrict the innovative interpretation of the requirement. This was particularly identified on HGS (Case Study 3) and SVC (Case Study 2). On HGS (Case Study 3) the change of Local Authority's requirement from 10% to 20% on-site renewable energy generation midway through the bidding process was perceived by ProjectCo actors as a considerable challenge and highly complicated the design process. The ProjectCo actors were frustrated in Local Authority actors' lack of appreciation of budget constraints and their limited understanding of the effect of such a change in the requirement on the ProjectCo's supply chain delivering the project. Indeed, the profitability of the whole project was questionable as a result of this change of requirement. The problematic issue of achievability of the sustainable energy requirement was also identified on SVC (Case Study 2), the project that did not include any implemented SEI. ProjectCo actors on this project were increasingly frustrated by the Local Authority's sustainable energy requirement of zero-carbon schools and the requirement was perceived to be 'unrealistic' both technically and financially at the time. The ProjectCo was forced to derogate against the requirement on the BSF PFI contract.

An important distinction could be made between the change of requirement midway through the process on HGS (Case Study 3), and the introduction of the novel operational carbon target of 27kg $CO_2/m^2/yr$ on BWS (Case Study 4) post Preferred Bidder. Contrary to HGS (Case Study 3), the introduction of the government's operational carbon target on BWS (Case Study 4) was not deemed controversial. While the carbon target was seen as challenging, there was, however, no controversy over meeting the target. In fact, the target encouraged the innovative biodiesel CHP solution; the first of its kind in a UK school building. The difference in perception among ProjectCo actors on HGS (Case Study 3) and BWS (Case Study 4) could be explained by the fact that on BWS (Case Study 4) the introduction of the carbon target midway through the process was coupled with the provision of the additional funding of £50/m^2 to meet the target. Therefore, the change of requirement midway through the process did not necessarily jeopardise the ProjectCo's profitability. This is in contrast to HGS (Case Study 3) where the change of requirement was not reflected in the original Outline Business Case (OBC), and, therefore, the scheme's funding. While Islington Council contributed additional funding to the project, the requirement was still deemed exhaustive. Previous innovation management studies have argued that policymakers can increase the pressure on the supply-side to develop new products and technologies by imposing requirements far too difficult for existing technologies to comply with, inducing demand for innovation (Gann and Salter, 2000; Barlow, 2000; Seaden and Manseau, 2001; Blayse and Manley, 2004). However, our case study findings suggest that such mechanisms should be implemented with caution. In fact, for such mechanisms to be effective in BSF PFI projects, the innovative requirement needs to be coupled with adequate funding. Greater alignment between the innovative sustainable energy requirement and the allocated budget may encourage ProjectCo actors to bring about environmentally as well as economically favourable innovations (Horbach, 2008), or what Porter and van der Linde (1995) termed 'economically benign environmental innovations'.

2. Clarity of the Governing Framework

In addition to their Output Specification, public sector actors that procure capital assets rely on governing frameworks that include regulation, standards and norms to ensure that the facilities delivered conform to the criteria of the specific context. ProjectCo actors across the four case studies agreed that the governing framework was made clear on BSF documentation. However, the study findings point out several deficiencies in the governing framework that discouraged ProjectCo actors from pursuing SEI. This is particularly in relation to (i) the inability of the BREEAM requirement to promote SEI; (ii) the rigid standards that designs needed to adhere to; and (iii) the low weighting of sustainability and energy issues on BSF bid evaluation criteria. These will be discussed below.

i. The Inability of the BREEAM Requirement to Promote SEI

The multiple case study findings, as outlined in Box F1.3, highlight the perceived inability of BREEAM to promote SEI and energy efficiency. The four local authorities depended on BREEAM to specify their sustainability requirement. While BEC (Case Study 1) was specified to BREEAM 'Very good', SVC (Case Study 2), HGS (Case Study 3), and BWS (Case Study 4) were specified to BREEAM 'Excellent'. Across the four case studies, ProjectCo actors agreed that BREEAM was successful in ensuring a certain level of sustainability. Indeed, on SVC (Case Study 2), the BREEAM 'Excellent' requirement was seen as the main driver for sustainability. This suggests that BREEAM does work to force contractors to ensure a certain level of environmental sustainability. However, ProjectCo actors across the four case studies agreed that BREEAM offered limited incentive to achieve exceptional results for energy efficiency and CO_2 reduction. Securing a BREEAM 'Excellent' rating may not necessarily indicate that the most energy-efficient building was achieved because credits can be scored for issues unrelated to the building. BREEAM also alters the strategies adopted by contractors. Contractors may install technologies in order to achieve BREEAM credits, while those technologies are unsuitable or inefficient. Other concerns were raised about BREEAM as a barrier to sustainability innovation in general. On HGS (Case Study 3) BREEAM was seen to restrict the development of innovative materials as it encourages the use of pre-identified materials from the Green Guide to Specification (BRE, 2009). The different BREEAM requirements between new-build and refurbishment projects on Leicester BSF (Case Study 2) also resulted in bespoke specifications for each school site rather than the Contractor purchasing all materials to the highest quality. The deficiency of BREEAM identified in our case studies echoes concerns raised by government departments such as the House of Commons (2007). There have been many calls in the construction industry for a much stronger response than BREEAM because no matter how high a project scored, that would not necessarily indicate low carbon emissions or carbon-neutrality.

ii. Rigid Design Standards

The multiple case study findings, as outlined in Box F1.4, suggest that the rigid design standards that the projects needed to adhere to inhibited innovation. This was particularly the case on HGS (Case Study 3), where the east elevation of the site overlooks a busy emergency route. The noise levels permitted by BB93 (School Acoustics) meant that the east elevation of the building had to be completely sealed off, and all rooms located on this side of the building (nearly 70% of the school area) needed to be mechanically ventilated (Transform Schools, 2007). The design team was increasingly frustrated in that there was no scope within BB93 to allow for any openings in the elevation. This restricted the opportunity to develop innovative solutions that may work to minimise noise levels whilst maintaining natural ventilation within those rooms. The tendency for design standards to inhibit innovation identified on HGS (Case Study 3) supports several studies that highlight regulatory policies as barriers to innovation in the construction industry (e.g. Larsson, 1996; Guy and Kibert, 1998; Bon and Hutchinson, 2000; Ngowi, 1998, 2001).

iii. Low Weighting on BSF Bid Evaluation Criteria

The multiple case study findings, as outlined in Box F1.5, indicate that the incentive for ProjectCo actors to innovate for improved energy performance was dampened by the low weighting of sustainability and energy issues on BSF bid evaluation criteria. Across the four case studies, the large number of issues involved on BSF bids meant sustainability and energy issues had a relatively low weighting on BSF bid evaluation criteria. In fact, on HGS (Case Study 3), some parts of Islington Council were frustrated in that BSF bid evaluation criteria did not adequately reflect Islington's strong corporate commitment to sustainability. ProjectCo actors on BEC (Case Study 1) and BWS (Case Study 4) also clearly indicated that their incentive to pursue SEI was not particularly driven by the weighting of sustainability in bid evaluation, but by their view of sustainability as a 'winning strategy' to differentiate their bids. Pursuing SEI was also seen by ProjectCo actors on BEC (Case Study 1) as a marketing strategy to strengthen the company's environmental credentials. Being known for having a 'green brand' has increasingly become crucial for the company's competitiveness and survival. This case study finding echoes Barlow and Köberle-Gaiser's research (2008ab) which highlighted that innovation was often considered a 'sales factor' when seeking to win bids in PFI projects. Indeed, the competitive nature of the BSF design process can encourage innovation, as a differentiating strategy by contractors. However, the low weighting of sustainability and energy issues on BSF bid evaluation may tip the balance in favour of other forms of innovation, rather than SEI.

In conclusion, the study findings identify that Proposition 1 is not supported on the case study projects. First, *Clarity of the sustainable energy requirement* was weakened across the case studies by its limited ‘specificity’ and ‘achievability’. Second, while *clarity of the governing framework* was achieved on BSF documentation, however, several deficiencies in the framework dampened ProjectCo actors’ incentive to pursue SEI. Particularly detrimental were the inability of BREEAM to promote energy efficiency, the rigid design standards that the design needed to adhere to, and the low weighting of sustainability and energy issues on BSF bid evaluation criteria.

10.2.2 Proposition 2: Findings

The study’s second proposition advances that SEI is supported by open communication and effective collaboration within the integrated ProjectCo, particularly among design, construction, and operation disciplines. The multiple case study findings, as outlined in Table F2 in Appendix F, however, indicate that Proposition 2 is not supported. Two key findings can be drawn to explain why the proposition is not realised across the case study projects. The findings are presented under two headings: (1) Openness of communication; and (2) Effectiveness of collaboration.

1. Openness of Communication

Many studies of CoPS have underlined the importance of multidisciplinary communication for successful innovation (Miller *et al.*, 1995; Hobday, 2000; Brady *et al.*, 2005). In the theory of PFI, the ProjectCo, assuming financial, design and operational responsibility for the fixed capital asset, is seen to provide system integration and coordination capabilities (Davies and Salter, 2006). Through their long-term commitment to the project, the ProjectCo is incentivised to make integration work and may, therefore, play a part in bringing together the expertise needed to protect its investment. This is seen to accelerate the design process, and stimulate innovation through improved communication (Barlow and Köberle-Gaiser, 2008b).

Across the multiple case studies, as outlined in Box F2.1, the Contractor appointed the Architect from an early stage. This has successfully ensured early constructability information influencing design decisions. However, the multiple case study findings, as outlined in Box F2.2, indicate that the ability of facility managers to contribute to SEI was largely underutilised. Across the four case studies, the Facility Manager was appointed by the ProjectCo, and not the Building Contractor, therefore, they were one step removed from the design team. The reluctance of the ProjectCo SPV, as the System Integrator (Barlow and Köberle-Gaiser, 2008b), to commit large resources into the bidding stage, due to the risks involved, also meant that facility managers had a limited degree of involvement during the bidding phase and their input post-bidding was restricted to maintenance issues. Facility managers were increasingly frustrated in suboptimal design solutions implemented by the design team, without consultation with facility managers. This was particularly the case on BEC (the problematic choice of the biomass storage system), SVC (ineffective BMS interface design) and BWS (ineffective BMS interface design, problematic BMS under-floor cabinet doors specification, and ill-positioning of lighting). Therefore, Proposition 2 findings indicate that the integrated design process espoused with the use of the PFI project delivery model in BSF has not actually translated into greater integration of the partners involved. It certainly did not result in the integration of facility managers into influencing design decisions. Design-Operation communication was restricted by the use of separate D&B and operational contracts to deliver the PFI project, which increases the distance between design and facility management teams and, thus, separates incentives to implement energy-efficient technologies from opportunities to do so. The limited involvement of facility managers in BSF design development processes is particularly detrimental, given the major role they can play in the energy-efficient operation of the building (Haji-Sapar and Lee, 2005).

2. Effectiveness of Collaboration

The multiple case study findings indicate that effective collaboration among ProjectCo actors towards SEI was influenced by two issues: (i) Alignment of objectives between architects and contractors, and (ii) Alignment of objectives between contractors and facility managers. The case study findings will be discussed below.

i. Alignment of Objectives between Architect and Contractor

The need for effective multidisciplinary collaboration was identified in many studies of CoPS innovation (Miller *et al.*, 1995; Hobday, 2000; Brady *et al.*, 2005). Previous PFI studies, such as that of Barlow and Köberle-Gaiser (2008b), argue that it is in the interest of the ProjectCo SPV to make sure that the objectives of architects, consultants and contractors are aligned and that they are working collaboratively. This may encourage innovation through greater collaboration (Barlow and Köberle-Gaiser, 2008b).

The multiple case study findings, as outlined in Box F2.3, however, suggest that there was an apparent conflict of objectives between architects and contractors and relationships between the two disciplines were particularly challenging across the four case studies. On BEC (Case Study 1), conflict of objectives occasionally occurred due to the Architect's desire to produce a 'statement' building and the limited budget available to the Building Contractor. On SVC (Case Study 2) the Architect was concerned that the BSF process allowed too much power to the Contractor and, thus, put the Architect in a position where key decisions were in the hands of the Contractor. The Architect's role was largely seen to focus on 'wow' factors and statement buildings and it was the Contractor who decided the building specification and, therefore, its sustainability. The Contractor's interest, on the other hand, was seen to initially win the contract and then meet the minimum sustainability requirement with the least cost. On HGS (Case Study 3), the relationship between the Architect and Building Contractor was challenging. According to the Architect, the Contractor saw sustainability as a 'burden' and was not in a 'state of readiness' to assess the design in the same way as the design team. The Architect found it difficult to commit the Building Contractor to the Architect's sustainable 'Design Intent'. On BWS (Case Study 4) the Architect felt controlled, restricted, and driven to 'tokenistic' and 'Eco-Bling' strategies by the Contractor. The design team also had fewer opportunities for having the quantity of consultants and experts that could be outside BSF. Sustainability initiatives promised during the bid were also compromised when new personnel joined the Contractor's delivery team, post Financial Close, and fought for tried and tested solutions rather than what was promised during the bid. Both Architects on HGS (Case Study 3) and BWS (Case Study 4) were frustrated that they had no access to cost information and poor exposure to the supply chain. Indeed, designers were exceedingly seen to be working under an 'awkward' position on BSF because their ability to pursue sustainability was largely dependent on contractors' and local authorities' preferences.

In summary, as our study suggests, the misalignment of objectives towards sustainable energy between design teams, particularly architects, and contractors in the BSF PFI delivery model complicates efforts to introduce SEI. In addition, the Architect's position within the Contractor-led D&B contract is highly restrictive to their innovative capacity. The balance of power on BSF PFI contractual structure is in favour of contractors and leaves architects in a position where key decisions are controlled by contractors. This significantly restricts innovative efforts by architects.

ii. Alignment of Objectives between Contractor and Facility Manager

The long-term contractual commitment of the ProjectCo is a prominent characteristic of PFI projects. Advocates of PFI argue that this long-term commitment places capital at risk and, thus, forces private producers to consider durability, functionality, and whole-life costs (HM Treasury, 2003). To achieve this, private actors are incentivised to consider the implication of design and construction decisions on the long-term operational performance of their asset (Leiringer, 2006). This is seen to support effective communication and collaboration among design, construction and operation disciplines, and thus, innovation benefits may accrue (Leiringer, 2006). However, the multiple case study findings identified that alignment of objectives between contractors and facility managers was influenced by two issues: (a) the ProjectCo composition, and (b) the introduction of joint objectives that align the interests of the Building Contractor with those of the Facility Manager.

a. The multiple case study findings, as outlined in Box F2.4, indicate that alignment of objectives between contractors and facility managers was influenced by the ProjectCo's composition. The three projects in which innovation was implemented, that is BEC (Case Study 1), HGS (Case Study 3) and BWS (Case Study 4), were delivered by integrated service companies. The integrated companies involved were Skanska PLC on BEC, Balfour Beatty PLC on HGS, and Carillion PLC on BWS. Those companies were responsible for the finance, design, construction, and operation of the facilities. The fourth case study, SVC (Case Study 2), on which no innovation was implemented, was delivered by a separated service company. The design and construction of the building was the responsibility of Miller Construction, while operation was the responsibility of G4S, a Facility Management Company which partnered with Miller during the pre-qualification stage. It can be observed from the multiple case study findings that the integrated service companies were more interested in the long-term energy performance of the building as opposed to the separated service company. Indeed, ProjectCo actors on the three innovative projects agreed that the ability of their company to deliver integrated services of design, construction, and operation was an incentive for the bid team to achieve the best possible energy solution because ultimately they are responsible for the energy charge. In contrast to that, the Building Contractor's Operations Manager on SVC (Case Study 2), the project that did not include any implemented SEI, expressed clearly that their responsibility, as the Building Contractor, ends when the building is handed over at the end of the initial period. He also added that it is for the Facility Manager to decide whether committing to the building for the next 25 years is worthwhile. This case study finding, therefore, indicates that the separation of companies responsible for construction and those responsible for operation may not be conducive to SEI on BSF PFI projects. As the Building Contractor carries no operational risk, they are not incentivised to improve the energy performance of the building beyond minimum requirements. Innovative energy solutions which are likely to result in increased initial capital cost to the Building Contractor are, hence, not welcomed. In fact, the findings suggest that arguments promoting the PFI project delivery model that focus on the operational benefits arising from ProjectCo integration should be taken with caution. While the size of our study limits the ability to arrive at a conclusive finding, it can be hypothesised that an integrated service company is more encouraged to implement SEI than a separated service company. Further research is needed to explore this relationship.

b. The multiple case study findings, as outlined in Box F2.4, suggest that alignment of objectives between the Building Contractor and Facility Manager can be strengthened by the introduction of joint sustainable energy objectives on the PFI contract. This was achieved on BWS (Case Study 4) by introducing the operational carbon target of 27kg $CO_2/m^2/yr$ and placing this obligation on the Building Contractor. As the Building Contractor was legally liable and financially responsible for any rectification needed for the building to meet this target, they were incentivised to take the operational energy performance of the building into consideration. By including specific energy success criteria in joint objectives, both the Building Contractor and Facility Manager explicitly declared that those aspects are important, which in turn aligned their objectives towards SEI. Indeed, the establishment of such joint objectives may ultimately lead to the achievement of a 'win-win' situation for both project development and operation.

In conclusion, the study identifies that Proposition 2 is not supported on the case study projects. First, *open communication* among design, construction and operation disciplines was weakened on the case study projects by lack of integration of Facility Management into influencing design decisions. Second, *effective collaboration* was weakened by misalignment of objectives among architects, contractors, and facility managers. While Architect-Building Contractor relationships were increasingly challenging across the four case studies, Building Contractor-Facility Manager relationships were shaped by the ProjectCo composition, and the introduction of joint operational energy objectives that align the interests of the Building Contractor with those of the Facility Manager towards SEI.

10.2.3 Proposition 3: Findings

The study's third proposition advances that SEI is supported by open communication and effective collaboration during BSF Local Authority-ProjectCo engagement processes. The multiple case study findings, as outlined in Table F3 in Appendix F, however, identify that Proposition 3 is not supported. Two key findings can be drawn to explain why the proposition is not realised across the case study projects. The findings are presented under two headings: (1) Openness of communication; and (2) Effectiveness of collaboration.

1. Openness of Communication

The importance of effective communication between clients and design teams for successful innovation was highlighted by several studies (e.g. Nam and Tatum, 1997; Bröchner and Grandison, 1992; Mitropoulos and Tatum, 1999, 2000). The case study findings suggest that open Local Authority-ProjectCo communication was influenced on the case study projects by two issues: (i) The nature of the BSF engagement process (Box F3.1), and (ii) The management of the Local Authority-ProjectCo interface (Box F3.2). The case study findings will be discussed below.

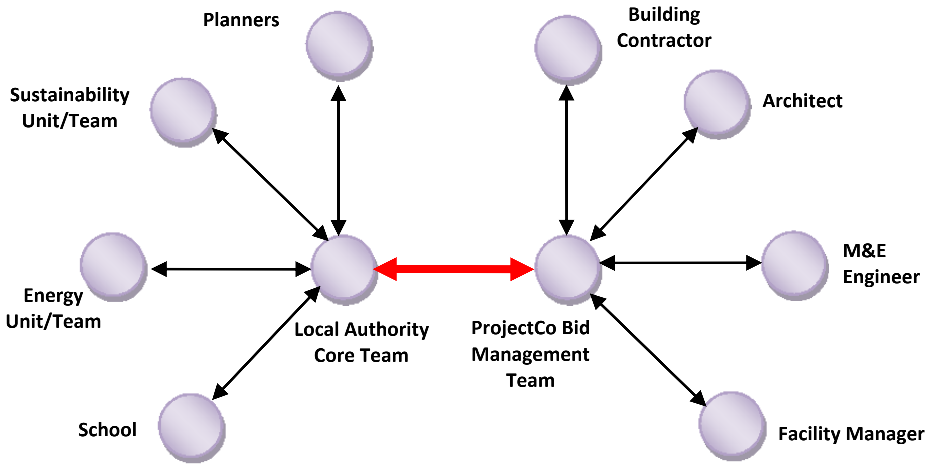
i. The Nature of the BSF Engagement Process

The multiple case study findings, as outlined in Box F3.1, underlined the inherent difficulties to Local Authority-ProjectCo communication brought in by the nature of the BSF engagement process. Across the multiple case studies, the BSF engagement process was seen to be 'intense', 'restricted', 'massively bureaucratic', 'cumbersome', 'time-consuming' and 'frustrating' to both local authorities' and ProjectCo actors. Communication was difficult because it needed to be equal and uniform across all bidders. It was also complicated by confidentiality issues. The magnitude of stakeholders involved during the engagement process highly complicated communication. There were many other elements discussed during BSF engagement meetings and design was only one element. Sustainability was not particularly high on the discussion agenda. Indeed, the BSF engagement process was seen to be prescriptive and involved a multitude of issues and, hence, it pushed environmental sustainability and energy issues further down the priority list. Indeed, highly formalised engagement procedures, such as in the case of BSF, complicate Client-Producer communication processes and fall short of recognising the long-term benefits of the additional upfront cost/ design time needed to establish a clear sustainable energy requirement specific to the client.

ii. The Management of the Local Authority-ProjectCo Interface

The multiple case study findings, as outlined in Box F3.2, indicate that the above barriers to communication presented by the nature of BSF engagement processes were overcome on the innovative projects by effective Local Authority-ProjectCo interface management by Core Teams. Across the multiple case studies, communication in the interface between ProjectCo actors and the different parts of the local authorities was managed by single points of contact in the form of the local authorities' Core Teams and the ProjectCo Bid Management Teams. Consensus developed across the multiple case studies of the usefulness of these single points of contact in facilitating clear information flow. Figure 10.1 illustrates the boundary-spanning activity in the interface between the ProjectCo, Local Authority and School.

Figure 10.1: Boundary-spanning Activities in the Interface between the ProjectCo, Local Authority and School



Source: Developed for this research study

However, the effective management of the Local Authority-ProjectCo interface by Core Teams varied across the multiple case studies. While Local authorities' Core Teams on the innovative projects were successful, to a greater or lesser extent, in facilitating sufficient communication between ProjectCo actors and their in-house sustainability expertise, this interface was tightly managed on SVC (Case Study 2), the project that did not include any implemented SEI. The multiple case study findings will be discussed below:

a. On BEC (Case Study 1) in order to introduce sustainability into BSF, the Core Team enlisted the help of the Council's in-house Sustainable City Team; responsible for coordinating and promoting sustainability initiatives across the Council and wider community. The Sustainable City Team was invited to take an active role in the BSF programme from its initial consultation stages and was heavily involved with ProjectCo actors throughout. The Sustainable City Team advised the BSF Project Management Team on sustainability issues and ensured that Bristol's environmental policies were supported throughout the process. However, the Core Team was unsuccessful in involving the Council's Energy Management Unit in discussion with ProjectCo actors. This was seen to be due to the limited interest in energy issues within the Core Team at the time. Communication between ProjectCo actors and the Energy Management Unit was ineffective throughout the process.

b. On HGS (Case Study 3) the Core Team built a Technical Team involving the key sustainability and energy expertise within the Local Authority. The Local Authority's in-house sustainability expertise in the form of the Sustainability Unit, Energy Management Unit and Planning Department were actively involved. The team also invited specialists in various areas to work with ProjectCo actors and review their sustainability proposals. Four-day-long meetings were exclusively held to discuss utilities, renewable technologies and Payment Mechanisms. The role of Islington's Sustainability Unit was also fundamental as the 'Sustainability Champion'. They supported the Core Team and acted as a source of sustainability knowledge across the Local Authority.

c. On BWS (Case Study 4), two consultation sessions were held to meet with ProjectCo actors and discuss their approach to sustainability in which the Core Team and sustainability advisors were able to challenge ProjectCo actors' proposals. Sustainability was seen to be 'embedded' in the Local Authority's procurement terms and was made clear to ProjectCo actors throughout the BSF process. The Core Team ensured that the strategies developed are directly linked to the Authority's corporate sustainability agenda. Key individuals within the Core Team, such as the Design Manager, also played the central role of the 'Sustainability Champion' promoting sustainability across the Local Authority and pushing its implementation on the BSF programme.

The case study findings, thus, identify the key roles played by local authorities' Core Teams, and the individuals within those teams in encouraging effective communication towards SEI. The key role played by Islington's (Case Study 3) and Nottingham's (Case Study 4) Core Teams depicts the role of the "Integration Champion" conceptualised by Hartmann (2008). Hartmann argues that successful innovation requires key individuals who can span the boundary between the client organisation and the innovative construction project and who actively support the adoption process to the client. Indeed, the importance of boundary-spanning roles is emphasised in many studies of innovation (e.g. Friedman and Podolny, 1992; Conway, 1997; Levina and Vaast, 2004; Stock, 2006; Hsu *et al.*, 2007). Our case study findings support those conceptualisations and shed the light on the critical role such actors play in promoting SEI on BSF PFI projects. These teams occupy a position with particular importance in the communication process, as they represent the single points of contact in the Local Authority-ProjectCo interface. In highly formalised engagement processes, such as in the case of BSF, explicit management of this interface by key boundary-spanners was necessary in order to facilitate effective dialogue towards SEI.

However, the case study findings, as outlined in Box F3.2, suggest that the situation was different on SVC (Case Study 2), the project where no SEI was implemented. The interface between ProjectCo actors and the Local Authority's in-house sustainability expertise was tightly managed by the Core Team. Leicester City Council was a 'Wave 1' Local Authority and there was a general lack of recognition within senior management of the intensity and volume of work needed to manage the BSF programme. The Core Team was largely perceived to work autonomously from other parts of the Local Authority. The Local Authority in-house sustainability expertise, in the form of the Environment Team, Property Services, and Sustainability Manager, were not involved in early consultation with ProjectCo actors and were unable to challenge their proposals. Engagement meetings were exclusively held between ProjectCo actors and schools. The limited involvement of the Local Authority's in-house sustainability expertise was due to lack of funding and capacity to secure their involvement at early stages. However, this lack of involvement highly affected the quality and depth of the information received by the ProjectCo. ProjectCo actors were particularly frustrated in the Local Authority's sustainable energy requirement of zero-carbon schools and the requirement was perceived to be unrealistic both technically and financially at the time. The lack of sufficient dialogue between the ProjectCo and the Local Authority made it difficult for both sides to reach consensus on realistic sustainability targets. It also meant that it was difficult for ProjectCo actors to clarify the Local Authority's commitment to sustainability, given other project's requirements and constraints.

The case study findings, therefore, demonstrate that the local authorities' Core Teams on the innovative projects succeeded, to a greater or lesser extent, in overcoming the difficulties to communication inherent in BSF engagement processes and ensured the involvement of their in-house sustainability expertise in discussion with ProjectCo actors. On the three innovative projects, ProjectCo actors agreed that the local authorities' clear commitment to sustainability and CO_2 reduction in their dialogue with bidders provided the teams with the incentive to pursue innovation for sustainability. Bidding for BSF projects involved high cost and risk and, therefore, the local authorities' clear commitment to sustainability and CO_2 reduction provided ProjectCo actors with the confidence that their innovative efforts would be rewarded in bid evaluation. The high cost and risk involved on BSF PFI bids, the multiple requirements involved, and the low weighting of sustainability on BSF bid evaluation criteria necessitated effective communication between the ProjectCo and the Local Authority to clarify the Local Authority's commitment to the issue. Indeed, the multiple case study findings indicate that, in essence, it was not the clarity of the sustainable energy requirement that was particularly encouraging to SEI (as was discussed in section 10.2.1).

Instead, it was the clear commitment of the Local Authority to sustainability and CO_2 reduction in its dialogue with ProjectCo actors that supported innovative efforts. It was this communication that clarified the sustainability requirement and allowed the Output Specification to be translated into an innovative sustainable design.

2. Effectiveness of Collaboration

The multiple case study findings identify that joint Local Authority-ProjectCo collaboration towards SEI was influenced by four issues: (i) Local Authority's 'Readiness to Deliver Sustainability'; (ii) Alignment of objectives between the ProjectCo and the Local Authority; (iii) Architect-Local Authority relationship; and (iv) The competitive nature of BSF engagement processes. The case study findings will be discussed below.

i. Local Authority's 'Readiness to Deliver Sustainability'

The multiple case study findings, as outlined in Box F3.3, identify that joint Local Authority-ProjectCo collaboration drove SEI on two of the innovative projects, particularly HGS (Case Study 3) and BWS (Case Study 4). On HGS (Case Study 3), the Architect and the Sustainability Unit were able to build a close collaborative relationship. The Sustainability Unit acted as a source of sustainability knowledge and expertise to the Architect. The innovative energy strategy was developed in close collaboration between the two, as the Sustainability Unit envisaged a large quota of renewable energy technologies to be implemented on the site. The Architect described the Local Authority and particularly the Sustainability Unit as being in a complete 'state of readiness' to push forward a very sustainable agenda and were influential in achieving the SEI outcome. On BWS (Case Study 4) effective collaboration towards SEI was facilitated by the 'receptive, supportive and encouraging' Core Team. The team was committed to sustainability, was knowledgeable enough to engage in a 'two-way' dialogue about its delivery, and was willing to accept new ideas.

However, joint Local Authority-ProjectCo collaboration was limited on BEC (Case Study 1) and SVC (Case Study 2). On BEC (Case Study 1), Local Authority actors were seen as 'broad-concept people' and unable to articulate their requirement. The ProjectCo collaboration with the Local Authority, particularly the Energy Management Unit, was ineffective throughout the process. On SVC (Case

Study 2), Local Authority actors were seen to lack adequate understanding of their sustainability requirement. Collaboration between the two parties was ineffective throughout. Our case study findings support arguments in the literature on the importance of client's competence and understanding of their objectives for successful collaboration towards innovation (Reich *et al.*, 1996; Tatum, 1997; Barrett and Stanley, 1999; Ive, 1996). It further emphasises its importance in sustainability innovation processes. In fact, the findings suggest that it was the Local Authority actors' 'Readiness to Deliver Sustainability', in terms of competence, understanding of their sustainability requirements, and determination to pursue a specific sustainable energy objective, one that defines and demands innovation, that was particularly important for SEI. Indeed, the concept of 'Readiness to Deliver Sustainability' is among the key characteristic of innovative local authorities identified in our study, and may warrant further attention from policymakers and researchers.

ii. Alignment of Objectives between the ProjectCo and the Local Authority

The multiple case study findings, as outlined in Box F3.4, indicate that effective collaboration towards SEI was restricted at times by misalignment of objectives between the ProjectCo and the Local Authority. This was identified on two of the innovative projects, particularly BEC (Case Study 1) and HGS (Case Study 3). It was also identified on SVC (Case Study 2), the project that did not include any implemented SEI. On BEC (Case Study 1), ProjectCo actors were concerned that Local Authority actors were pushing sustainability without adequate appreciation of budget constraints. The inability of the ProjectCo to incorporate high-cost PVs on site was a source of dispute between ProjectCo actors and the Sustainable City Team. Local Authority actors, on the other hand, felt that their objectives were misaligned with the objectives of the 'profit-seeking' contractors.

On HGS (Case Study 3), relationships between the Architect and the Local Authority, particularly the Sustainability Unit were highly collaborative, as was discussed earlier. However, relationships became confrontational and difficult post Financial Close, particularly between Local Authority actors and the Building Contractor. Some tension increasingly developed in relation to what the Local Authority wanted to achieve for sustainability, and the BSF budget allocated to the Building Contractor. Mistrust and technical disputes dominated the relationship for some time. The energy statement also resulted in extensive debate throughout the process. Beyond competitive dialogue, Local Authority actors were no longer capable of controlling the information they received or the amount of dialogue that took place. ProjectCo actors' reluctance to engage with the Local Authority post-bidding was explained by the Building Contractor's fear that active engagement would complicate the design process and lead to unrealistic sustainability demands. Indeed, the lack of Local Authority actors' understanding of budget constraints was frustrating to ProjectCo actors and increased their unwillingness to engage with the Local Authority.

On SVC (Case Study 2), the project that did not include any implemented SEI, ProjectCo actors also perceived Local Authority actors as lacking adequate understanding of budgetary constraints. The Local Authority's requirement of zero-carbon schools was seen to be unrealistic both technically and financially at the time, and was seen to stem from Local Authority actors' lack of appreciation of the limited budget available. Post Financial Close, Local Authority actors felt they had no power or influence, with the project dominated by the Building Contractor. The Building Contractor's objective was seen to meet the environmental requirements, with the minimum cost, in order to make the project profitable. To conclude, while it is often argued that alignment of objectives among project participants is a key condition for successful innovation (Hobday, 1998; Dulaimi *et al.*, 2003), there remain conflicts of interest among Local Authority and ProjectCo actors that restrict the development of collaborative relationships towards SEI.

iii. Architect-Local Authority Relationship

The multiple case study findings, as outlined in Box F3.5, indicate that the Architect-Local Authority relationship was particularly restricted on BSF. Across the four case studies, architects were working under building contractors from an early stage and, therefore, were one step removed from the local authorities. Apart from HGS (Case Study 3), this restricted the opportunity to build close working relationships as the time spent with the local authorities was significantly less than a conventional client. It also weakened the ability of the design to develop and mature. The restricted Architect-Local Authority relationship on BSF is potentially detrimental to SEI as it may complicate the introduction of sustainable solutions into the design process.

iv. The Competitive Nature of BSF Engagement Processes

The multiple case study findings, as outlined in Box F3.6, identify that the competitive nature of BSF engagement processes presented further challenges to joint Local Authority-ProjectCo collaboration towards SEI. On BEC (Case Study 1), the Local Authority tended to 'play one bid against the other', which had put ProjectCo actors under extreme pressure whilst bidding and made it more difficult for them to win the bid. ProjectCo actors were also concerned that Local Authority actors tended to 'level out' bids which resulted in bids becoming similar, and restricted innovation. As the design process was running concurrently with bidding, ProjectCo actors feared that suggesting high-cost sustainable technologies could jeopardise affordability and result in the ProjectCo failing to win the bid. On HGS (Case Study 3) ProjectCo actors feared giving away good ideas whilst bidding. They were also reluctant to invest in CHP models and put too much time and resource into their design whilst bidding due to the risks involved. The competitive nature of the design process often meant that there was a need to reach a synthesis between what is attractive and what works in terms of the energy efficiency of the building. This was an issue on both BEC (Case Study 1) and SVC (Case Study 2). Indeed, the case study findings suggest that fear of losing the bid may lead to pursuing aesthetical quality rather than sustainability on BSF PFI projects. In addition, as Preferred Bidder is selected on RIBA stage D design work, detail design done afterwards can result in sustainability being compromised. In fact, concerns were raised by local authorities' actors on HGS (Case Study 3) and BWS (Case Study 4) regarding the difficulties of ensuring that sustainability promises made by ProjectCo actors during the bid are actually delivered afterwards. The amount of time allocated to the BSF design process was also a source of concern to ProjectCo actors. On SVC (Case Study 2) the limited time allocated to the design process restricted the development of the necessary energy models for energy-efficient design. This was later reflected in the low quality of bids that the Local Authority received. The Architect on BWS (Case Study 4) also highlighted that, as Financial Close was signed on RIBA stage F design drawings, the limited time between Preferred Bidder and Financial Close meant that design needed to move rapidly from stage D to F. Consequently an important design stage, stage E, was often lost on BSF.

In conclusion, the study identifies that Proposition 3 is not supported on the case study projects. First, *open communication* was weakened across the four case studies by the restrictive nature of the BSF engagement process. The process involved a multitude of issues and, therefore, it pushed environmental sustainability and energy issues further down the priority list. Second, while *effective collaboration* drove SEI on two of the innovative projects, this was often interrupted by misalignment of objectives between the ProjectCo and the Local Authority, the restricted Architect-Local Authority relationship, and the competitive nature of BSF engagement processes.

10.2.4 Proposition 4: Findings

The study's fourth proposition advances that SEI is supported by open communication and effective collaboration during BSF School-ProjectCo engagement processes. The multiple case study findings, as outlined in Table F4 in Appendix F, however, identify that Proposition 4 is not supported. Two key findings can be drawn to explain why the proposition is not realised across the case study projects. The findings are presented under two headings: (1) Openness of communication; and (2) Effectiveness of collaboration.

1. Openness of Communication

Effective communication between design teams and users is often cited as a key ingredient for the successful implementation of any sustainability or environmental initiative on projects (e.g. Rohracher, 2003, 2005; Ornetzeder and Rohracher, 2006; Heiskanen and Lovio, 2007). The multiple case study findings, as outlined in Box F4.1, identify that communication between ProjectCo actors and schools across the four case studies was enabled by the dedicated BSF engagement meetings. The four schools enjoyed a great deal of power under BSF as they took part in writing their requirements, in engagement with ProjectCo actors, and in evaluating the bids. In fact, BSF presented a significant improvement from early PFI school deals where no amount of consultation was undertaken with schools and contractors simply arrived and started building a new facility[11]. The schools' commitment to the BSF programme was also a key driver for their active involvement. The four schools involved in our study saw BSF as a once-in-a-lifetime opportunity to improve the lives of their children and the community they serve. Therefore, schools invested considerable time and effort in their engagement with ProjectCo actors. The engagement process also benefited from committed individuals such as the 'strong and charismatic' Head Teacher of BEC (Case Study 1) and the committed School Engagement Teams of SVC (Case Study 2) and BWS (Case Study 4).

[11] An example of schools' limited involvement in early PFI deals is Edwards and Shaoul's (2003) case study on the re-development of Pimlico School, Westminster City Council.

However, the multiple case study findings, as outlined in Box F4.1, indicate that the BSF engagement process was unsuccessful in facilitating open communication between ProjectCo actors and schools. Across the four case studies, communication between ProjectCo actors and schools was seen to be 'formal' 'cold', 'rigid', and 'very difficult'. Engagement meetings were tightly managed by the local authorities' Core Teams and the schools' ability to discuss the design freely with ProjectCo actors was limited by the competitive nature of the process. In fact, the Bid Manager on BEC (Case Study 1) argued that schools were somewhat 'policed' during their engagement with bidders. Schools were briefed to be impartial and non-partisan and the engagement process was often complicated by the large number of representatives from the local authorities. The school community on BEC (Case Study 1) tended to transfer the best design ideas from one bid to the other through the engagement process. While this was done in a way that did not jeopardise PFI guidance (such as HM Treasury, 2000a), it put ProjectCo actors under considerable pressure whilst bidding. The engagement process was also seen to be massively time-consuming and exhausting for schools as they needed to attend a large amount of meetings with the shortlisted bidders. Schools were also increasingly frustrated in the lack of recognition of the pressure that the BSF process puts on a school. The School Engagement Teams were still expected to carry out their daily responsibilities of teaching and managing the school, whilst taking part in BSF meetings, which was exhausting. Communication between design teams and schools was also complicated by the fact that design teams were working under building contractors from an early stage and, thus, one step removed from schools. However, communication changed after the appointment of the ProjectCos as Preferred Bidders from being 'generic' and equal for all bidders to being 'specific'. The design teams involved had the opportunity to talk directly to schools and local communities. Schools were able to target their comments specifically to their winning design. Nevertheless, this was seen to be too late in the process as many design decisions were already taken by then. In summary, it can be argued that the failure of schools to contribute fully to the innovative design process was restricted, in part at least, by the BSF process itself. Indeed, the BSF process lacks adequate appreciation of the long-term benefits of engaging schools in expressing their sustainability aspirations, building their awareness, and developing their capabilities.

2. Effectiveness of Collaboration

Effective collaboration with users is seen to be particularly important for sustainability and environmental innovations, which often seek to find alternative and radically innovative solutions to fulfil user needs in a more eco-efficient manner (Kaatz, *et al.*, 2005; Rohracher, 2003, 2005; Heiskanen *et al.*, 2007). The multiple case study findings, as outlined in Box F4.2, indicate that the ability of ProjectCo actors to involve schools in discussions about sustainability was supported by the schools' interest in the educational benefits of a sustainable design. The four schools involved saw the pursuit of a sustainable solution as an opportunity to enrich the school curriculum and to educate their pupils about sustainability. Their role as exemplars for sustainability within their community was also motivating for the schools to consider a sustainable solution for their building. This echoes work by Reich *et al.* (1996) which suggests that the motivation for users to engage in innovative activities may be stimulated by the 'trace' or impact of the building on their community.

However, despite that, the multiple case study findings, as outlined in Box F4.2, highlight that joint School-ProjectCo collaboration towards SEI was somewhat ineffective. Across the four case studies sustainability was seen not to be high on the schools' agenda. Schools' priority was fundamentally their educational requirements and delivering transformational learning environments for their pupils. In addition, the schools' ability to effectively contribute to discussions about sustainability was seen to be limited by their lack of technical knowledge about the subject.

Moreover, ProjectCo actors expressed the difficulty of balancing the schools' transformational learning aspiration and energy conscious design. This was observed on BEC (Case Study 1), SVC (Case Study 2) and BWS (Case Study 4). On BEC (Case Study 1) and SVC (Case Study 2) the schools' aspiration for large and uplifting social spaces resulted in the schools' area significantly exceeding the area requirements of BB98 (Briefing Framework for Secondary School Projects). This consequently led to higher lighting and heating demands, largely contradicting the energy efficiency objective. The Project Architect on BWS (Case Study 4) also highlighted the delicate balance between achieving outstanding results for energy efficiency, whilst delivering transformational environments internally and externally for the school. Schools' requirements may also contradict the objective to reduce their overall CO_2 emission. This was the case on HGS (Case Study 3) where the school's reluctance to reduce the number of car parking spaces allocated in their site largely affected the school's overall carbon footprint.

Sustainability was also restricted by the conflict between the schools' educational requirement and the sustainability requirements due to the limited BSF budget. This was particularly the case on BEC (Case Study 1) and SVC (Case Study 2). On BEC (Case Study 1), the limited BSF budget meant that the school was often faced with a difficult trade-off between investing in the school's educational requirement and improving the sustainability of their building. Evidence of this was also found on SVC (Case Study 2) where several sustainability elements were engineered out during affordability negotiations (such as the Virtual Energy Centre).

In addition, an important inhibitor for joint School-ProjectCo collaboration was the schools' limited interest in energy issues as a result of their reduced control over their building under PFI. As PFI schools, the management of the building is the responsibility of the operator who oversees all aspects of the building, including its energy performance. Therefore, energy issues are not particularly important to schools, because ultimately they are not responsible for the energy charge. In the literature, von Hippel (1988) points out that the motivation for users to participate in innovative activities rests on their ability to benefit from the results of the innovation. The research findings support this view and may offer further explanation to users' incentives to collaborate in sustainable innovation processes. Particularly, the research findings suggest that contractual User-Producer relationships may strongly define these espoused innovation benefits. The research findings suggest that contractual practices that remove the responsibility of the facility's energy performance from users offer limited incentive for users to consider the operational energy performance of the building as their main concern.

In conclusion, the study identifies that Proposition 4 is not supported on the case study projects. First, *open communication* was restricted by the 'formal', 'cold', 'rigid' and 'very difficult' nature of the BSF engagement processes. Second, *effective collaboration* was also weakened by schools' limited responsibility over the energy performance of their building under the PFI contract, resulting in sustainability and energy efficiency issues being further down their priority list. Indeed, schools' priority was fundamentally their educational requirements and delivering transformational learning environments for their pupils.

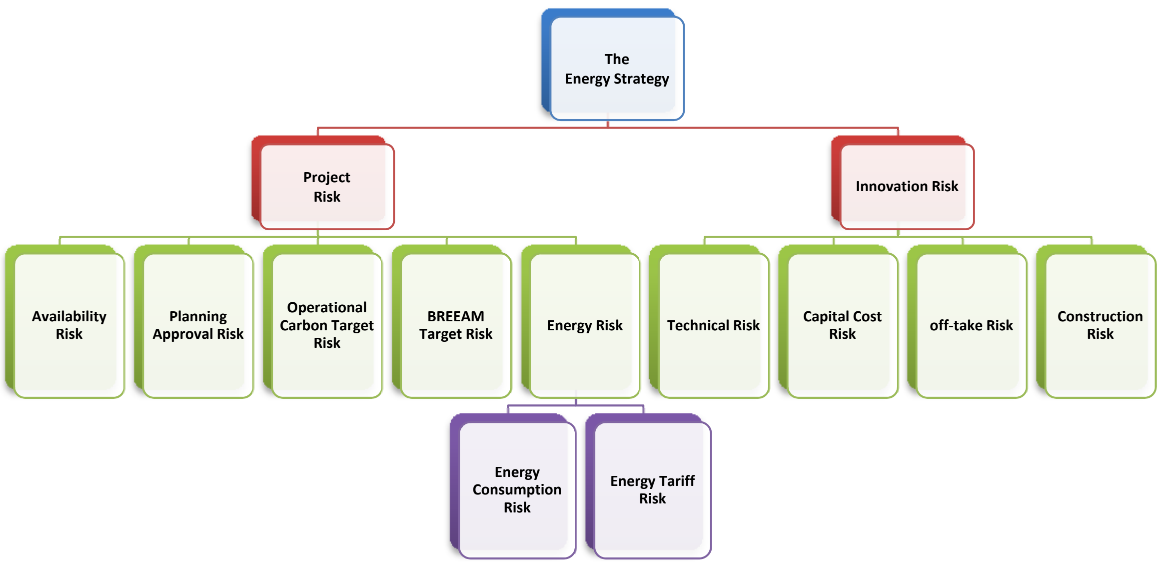
10.2.5 Proposition 5: Findings

The study's fifth proposition advances that the implementation of SEI is supported by clear, appropriate, and manageable allocation of the risks associated with the project's energy performance. The multiple case study findings, as outlined in Table F5 in Appendix F, identify that Proposition 5 is supported. Three key findings can be drawn to explain how the proposition was realised on the case study projects. The findings are presented under three headings: (1) Clarity of risk allocation; (2) Appropriateness of risk allocation; and (3) Manageability of risk allocation.

1. Clarity of Risk Allocation

The multiple case study findings, as outlined in Box F5.1, identify that the energy strategies developed on the four case study projects were influenced by the allocation of two types of risk to ProjectCo actors: project risk, and innovation risk. Project risks, as they relate to the energy strategy, are those assumed by ProjectCo actors in relation to the project meeting agreed environmental and energy performance standards. Innovation risks are those assumed by the innovating organisation in relation to the extent to which the innovation satisfies various technical criteria without increased cost of development, production or operation. The interplay between those two types of risk shaped the energy strategies and the innovations implemented on the case study projects. Figure 10.2 illustrates the main risks identified.

Figure 10.2: Main Identified Risks Associated with the Energy Strategy



Source: Developed for this research study

In addition, Table 10.2 below defines the main risks identified and the party to whom the risk is allocated under the BSF PFI contract.

Table 10.2: Main Identified Risks and the Party Assuming the Risk

Risk	Definition	Risk Allocation
Project Risks:		
Availability Risk	The risk that the building's environment fails to meet agreed environmental criteria and, thus, incurring availability penalties.	ProjectCo SPV
Energy Risk	*Energy Consumption Risk:* the risk that the building's operational energy consumption is beyond agreed standards for maximum annual energy consumption in the contract.	ProjectCo SPV/ FM
	Energy Tariff Risk: the risk of fluctuations in the market price of energy.	ProjectCo SPV/ FM for the first three years. Subsequently retained by the Local Authority
BREEAM Target Risk	The risk that the building fails to achieve the BREEAM target and, hence, incurring penalties.	Building Contractor
Operational Carbon Target Risk	The risk that the building fails to meet the operational carbon target of 27kg $CO_2/m^2/yr$ and, hence, incurring penalties.	Building Contractor
Planning Approval Risk	The risk that the building specification/energy strategy adopted fails to achieve the terms of planning permission.	Building Contractor
Innovation Risks :		
Technical Risk	The risk that the innovative solution adopted fails to meet technical criteria set by the innovating organisation and/or the contract.	The innovating organisation
Off-take Risk	The risk that the demand for the heat load produced by the innovative solution (e.g. district heating networks) is under or overestimated.	The innovating organisation
Capital Cost Risk	The risk that the innovative solution adopted fails to meet project budget and, hence, rejected as being unaffordable.	The innovating organisation
Construction Risk	The risk that the innovative solution adopted fails to be delivered to agreed specification, schedule or budget.	The innovating organisation

Source: Developed for this research study

In the literature, greater clarity of risk allocation is seen to reduce the financial and legal uncertainty faced by the innovating organisation and support rational decision making, which may benefit innovation (Leiringer, 2006; Barlow and Köberle-Gaiser, 2008b). The multiple case study findings, as outlined in Box F5.1, identify that ProjectCo actors on the innovative projects agreed that the risks associated with the project's energy performance were generally made clear early in BSF documentation. This potentially benefitted innovation efforts. However, the case study findings indicate that the situation was different on SVC (Case Study 2), the project that did not include any implemented SEI. On SVC, the Building Contractor lacked adequate understanding of the BREEAM 'Excellent' requirement. There was also limited assessment of the requirement's implications on the project's costs and time constraints. Indeed, post Financial Close, as there were penalties associated with meeting the requirement, the amount of time and resources needed to achieve it was a considerable challenge to the Building Contractor. This lack of understanding was explained by the newness of the requirement itself to the Building Contractor. As Leicester was a 'wave 1' Local Authority and the first BSF project to the Building Contractor, the environmental requirements associated with it, including BREEAM, were clearly underestimated. The requirement was eventually met but at a considerable cost, in terms of time and resources. Therefore, as the study findings suggest, identifying the environmental risks transferred to ProjectCo actors is only one element of a successful risk management strategy; assessing those risks and understanding their implications are equally vital. The newness of some environmental requirements to firms, such as BREEAM, demands sufficient assessment of their impact on the planned course and objectives of the project. Without such assessment, it is likely that adequate understanding of what is needed to deliver the requirements, and manage the associated risks, will be weak.

2. Appropriateness of Risk Allocation

Most government guidelines advocate that risk should be allocated to the party best placed to control and manage it (UNIDO, 1996; HM Treasury, 2003). Blayse and Manley (2004) and Leiringer (2006) also stress the need for equitable allocation of risk among project participants. The multiple case study findings, as outlined in Box F5.2, indicate that ProjectCo actors across the four case studies perceived the risks associated with the project's energy performance to be appropriately allocated, apart from two incidents. The appropriateness of risk allocation was challenged by the perceptions of the ProjectCo Whole Life Cost (WLC) Director on HGS (Case Study 3) and the Building Contractor's Education Director on BWS (Case Study 4). The ProjectCo WLC Director on HGS (Case Study 3) argued that the Building Contractor assuming the initial energy consumption risk was somewhat unfair. This was explained by the difficulty to accurately predict energy consumption targets during the design process; the long time buildings need to settle into their natural level of performance; and the significant influence of end-user behaviour on energy consumption as opposed to the actual building itself. In addition, the Building Contractor's Education Director on BWS (Case Study 4) agreed that the risk associated with the government's carbon target of 27kg $CO_2/m^2/yr$ was fairly allocated to the Building Contractor. The Building Contractor was responsible for the design and construction of the building and was, thus, best placed to manage the risk. However, the Building Contractor's Education Director questioned the CO_2 target itself and felt the target was onerous and difficult to completely close down. The success of any mitigation strategy was seen to be difficult to predict and can only be clear after the building is operational for a period of time. The case study findings, therefore, indicate that while the risks associated with the project's energy performance were generally considered appropriately allocated, there were incidents when ProjectCo actors thought that they had been forced to assume risks that were difficult to manage. This perceived inappropriateness of risk allocation can be potentially harmful to SEI as the OECD (2005) considers excessive perceived risk as one of the main barriers to innovation.

In addition, ProjectCo actors across the four case studies highlighted the conflicting environmental requirements that needed to be met under the BSF PFI contract. The ProjectCo needed to balance the Availability Clause which requires teaching spaces not to exceed 28°C for more than 120 hr/yr during core summer hours, whilst meeting agreed standards for maximum annual energy consumption in the PFI contract. The strategies adopted to achieve these conflicting requirements were mainly to reduce the demand for the energy required to cool those spaces through passive design principles, whilst maintaining the efficiency of the supply as much as possible. However, ProjectCo actors across the four case studies argued that the Availability Clause and temperature tolerances forming part of its criteria were potentially detrimental to energy efficiency and CO_2 reduction objectives. Excessive perceived availability risk may force contractors to install carbon-intensive technologies, such as HVAC, to ensure teaching spaces do not exceed 28°C and safeguard their long-term investment in the project. This is particularly detrimental in situations where penalties for non-availability considerably exceed penalties for not meeting annual energy consumption targets. Indeed, it can be argued that the temperature tolerances forming part of the Availability Clause may represent a considerable challenge to achieving the government's target of zero-carbon schools by 2016 through PFI contracts.

3. Manageability of Risk Allocation

The multiple case study findings, as outlined in Box F5.3, indicate that manageability of the risks allocated to ProjectCo actors was an important criterion when implementing SEI. While the allocation of several types of risk to ProjectCo actors was considered manageable and, in fact, drove SEI, the allocation of others was considered excessive and difficult to manage within the BSF PFI environment. The interplay between those perceived risks shaped the energy strategies and the innovations implemented on the case study projects. The multiple case study findings are presented under two headings: (i) The management of risk as driver for SEI; and (ii) Unmanageability of risk as barrier to SEI.

i. The Management of Risk as Driver for SEI

The multiple case study findings, as outlined in Box F5.3, identify that the allocation of several types of risk to ProjectCo actors encouraged SEI to be pursued. In fact, the SEIs implemented on the three innovative projects were largely developed as strategies to manage several types of risk allocated to ProjectCo actors. The key risks identified are as follows:

a. ***Perceived availability risk*** was a major consideration across the three innovative projects. Not meeting the availability criteria exposes the ProjectCo to payment deductions as part of performance monitoring linked to the Payment Mechanism. Availability risk was particularly a major consideration on BEC (Case Study 1), where the risks associated with the availability criteria were identified, evaluated, and the related financial penalties were deemed significant enough to influence the design process. The risk-averse attitude of the ProjectCo and their desire to protect their investment in the long-term resulted in setting challenging environmental targets for the design team to meet. In order to reach an extremely robust and safe design, teaching spaces were designed so as not to exceed 28°C for more than 20 hr/yr rather than the allowed 120 hr/yr under the BSF PFI contract. This was an extremely ambitious target at the time and was pushing the boundaries of what could be achieved for sustainability. The design team needed to meet the target, whilst maintaining agreed standards for maximum annual energy consumption in the PFI contract. The target led to the development of the innovative ventilation chimney which ensured excellent air flow across the classrooms, minimising the need for mechanical ventilation and significantly reducing energy consumption during operation.

b. ***Perceived energy consumption risk*** was a major consideration across the three innovative projects. Not meeting energy consumption targets exposes the ProjectCo to payment deductions as part of performance monitoring linked to the Payment Mechanism. On HGS (Case Study 3), energy consumption risk was particularly a major consideration. The design team was presented with challenging site constraints, particularly the adjacency of the site to a busy emergency route, which meant that 70% of the building needed to be mechanically ventilated (Transform Schools, 2007). The team evaluated several energy strategies in order to increase the likelihood of meeting the energy consumption targets, while providing an internal environment comfortable to the school. The strategy adopted was to minimise the demand for energy, by increasing the building's thermal mass and improving air leakage rates and U-values, as well as maintaining the efficiency of the supply as much as possible. The innovative energy supply strategy was a new combination of best available sustainable technologies in the market (mini-Combined Heat and Power Plant, Ground Source Heat Pump, Earth Tubes, and mini-Wind Turbine) to spread the risk across several technologies, energy providers, and users within the school.

c. ***Perceived operational carbon target risk*** encouraged SEI on BWS (Case Study 4). BWS was among the first BSF schools to bid for and be successfully awarded the DCSF additional funding of £50/m² to achieve the challenging target of 60% reduction in carbon emission (compared to a school being constructed to the energy efficiency standards set out in the 2002 Part L Building Regulation). The target was translated into an operational carbon target of no more than 27kg $CO_2/m^2/yr$ emission during core hours, which is a contractually binding operational obligation placed on the Building Contractor and linked to the Payment Mechanism. The innovative biodiesel CHP solution was implemented to ensure that the building meets this operational target, significantly reducing the school's dependence on electricity from the national grid.

d. ***Perceived planning approval risk*** encouraged SEI on two of the innovative projects. On HGS (Case Study 2) the innovative energy supply solution ensured that the project is meeting Islington's planning requirement of 20% renewable energy generation. On BWS (Case Study 4) the CHP solution was also successful in meeting Nottingham's planning requirement of 20% on-site renewable energy generation. It should be noted that, on BEC (Case Study 1), the requirement lacked site-specific targets for carbon reduction or on-site renewable energy generation, as Bristol planning policy did not require it at the time.

Two key observations could be made from the above case study findings. First, the study findings suggest that the allocation of long-term energy performance risks to ProjectCo actors may have worked to encourage SEI. On PFI projects, the two specific mechanisms the Local Authority uses to achieve this risk allocation are the Output Specification and the Payment Mechanism (Rintala, 2004). As the Local Authority cannot readily measure the amount of resources the ProjectCo requires producing the service, it heavily relies on measuring the output of the service provision and linking the Unitary Payment for the service to that output (Douma and Schreuder, 1998; Grout, 1997). In the case of the building's energy performance, the Local Authority measures the energy consumption of the building, and links the Unitary Payment to that performance. Not meeting energy consumption and CO_2 targets exposes the ProjectCos to payment deductions as part of performance monitoring linked to the Payment Mechanism. Therefore, the ProjectCo is incentivised to avoid penalties for non-compliance and are, thus, likely to ensure that the building meets agreed energy performance standards. This study finding provides empirical evidence to the importance of risk allocation as a driver for sustainability innovation. Indeed, our findings suggest that contract practices that allocate long-term energy performance risks to producers may support SEI effort. In addition, our case study findings differ from previous PFI innovation research conducted by Barlow and Köberle-Gaiser (2008ab) which suggests that the desire to transfer as much risk as possible to ProjectCo actors was not conducive to innovation. The findings of our research study differing from Barlow and Köberle-Gaiser's (2008ab) can be explained by the nature of the innovations implemented. Barlow and Köberle-Gaiser studied innovations for adaptability of the design to future changing needs in Hospital PFI projects. They have noticed that, in fact, there is a disincentive for the ProjectCo to plan for adaptability because it could achieve additional income through alterations needed in the future. In our research, on the other hand, innovations for energy efficiency are directly linked to the ProjectCo future revenue as a result of the ProjectCo responsibility for meeting agreed energy consumption and CO_2 emission targets in the duration of the concession period. Energy efficiency also implies future financial savings and returns by reducing the cost of building operation. Therefore, SEIs are directly linked to the long-term profitability of the ProjectCo and are, thus, favourably perceived.

Second, the multiple case study findings, as outlined in Box F5.4, identify that ProjectCo actors pursuing SEI on the three innovative projects were inevitably faced with innovation risks that needed to be managed. Innovation risks were defined by Leiringer (2003) as "those faced by the innovating company in relation to the extent to which the innovation satisfies various technical criteria without increased cost of development, production or operation" (p. 95). The case study findings identified the strategies adopted by ProjectCo actors to manage those risks. These will be discussed below:

a. On BEC (Case Study 1), technical risk associated with the development of the ventilation chimney was managed by undertaking numerous prototyping and simulation tests. The knowledge and expertise of the design team provided further assurance. Technical risk was also minimised by developing a design that was predominantly a new combination of tried and tested technologies. Reliability was therefore an important criterion and the developed design was not to be 'too experimental' to safeguard the ProjectCo SPV investment and long-term commitment to the project.

b. On HGS (Case Study 3), the innovative energy supply strategy was developed by the Design Consultant (BDP), a company with extensive sustainability expertise. The energy simulation models developed at the design stage were critical, not only to ensure the targets were met, but also to minimise the risk for the ProjectCo and Building Contractor. Technical risk meant that the solution adopted was not necessarily a novel concept but a new combination of the best technologies available in the market in order to spread the risk across the various technologies.

c. On BWS (Case Study 4), technical risks associated with the innovation were managed by improving the team's technical knowledge and appointing an Energy Consultant. The role of the ProjectCo's Bid Director was also crucial in coordinating the innovation process and overcoming resistance to change within the design team. In addition, the innovation was not necessarily a high-risk strategy and the biodiesel CHP was purchased from a well-known German manufacturer.

Two key observations could be made from the above case study findings. First, technical risks arising from innovation were managed across the multiple case studies by improving the technical knowledge base of the team. The experienced design teams of BEC (Case Study 1) and HGS (Case Study 2) as well as the appointment of the Energy Consultant on BWS (Case Study 3) provided assurance to the ProjectCo that the developed innovations were well-resourced. Therefore, the development of SEI in our case studies required sufficient technical and sustainability knowledge within the team for the ProjectCo to innovate successfully. It should be noted that while the energy strategy on SVC (Case Study 2) was largely conformance-based and no innovation was implemented, still the risks associated with meeting the BREEAM 'Excellent' requirement were managed by improving the team's technical knowledge base and appointing an external consultant to act as a BREEAM 'policeman'.

Second, the multiple case study findings identify that the innovations implemented were closely following best practice. The chimney design in BEC (Case Study 1) was a combination of tried and tested technologies. HGS's (Case Study 3) energy supply strategy was based on a new combination of best available technologies. BWS's (Case Study 4) Biodiesel CHP plant, although new in UK school buildings, was a well-known technology and was purchased from an established German manufacturer. In all three case studies there was existing evidence to suggest that these technologies can be successfully implemented. Reliability of the technology was an important criterion as it reduced the uncertainty associated with the innovation and provided further assurance to the ProjectCo. Indeed, as our study suggests, the nature of the BSF PFI contract often drives ProjectCo actors to adopt tried and tested technologies in order to minimise their risk exposure. In addition, the case study findings indicate the type of SEIs most likely to be implemented on BSF PFI projects. The main SEIs could be considered as adaptation of existing systems to new context, or combination of well-known technologies. Therefore, it can be argued that SEIs within BSF PFI projects are more likely to be incremental (Lutzenhiser and Biggart, 2003; Slaughter, 1998) and exploitative (March, 1991; Holmqvist, 2004) rather than radical (Slaughter, 1998) or explorative (March, 1991; Holmqvist, 2004). Previous research, such as CIC (2000) and Leiringer (2003) highlighted this incremental nature of most innovation on PFI projects. However, this bias towards incremental innovation may weaken the capacity of PFI contracts to deliver the government's zero-carbon objectives as more radical and system innovations are required to deliver such significant reductions in carbon emissions (Huesemen, 2003; Enkvist *et al.*, 2008).

ii. Unmanageability of Risk as Barrier to SEI

The multiple case study findings, as outlined in Box F5.5, indicate that excessive perceived risk discouraged SEI on SVC (Case Study 2). It also discouraged ProjectCo actors on the innovative projects, being BEC (Case Study 1), HGS (Case Study 3), and BWS (Case Study 4), from pursing further SEI. The case study findings will be discussed below:

a. Excessive perceived ***capital cost risk*** inhibited the adoption of high-cost technologies with extended payback periods. Across the four case studies, the long-term commitment of the ProjectCos to the projects did not justify investment in high-cost technologies because payback periods were equally important. Being in a competitive bidding process, affordability was also a major consideration. In fact, the biggest challenge for sustainability was seen to be cost and trying to achieve it within the allocated 'Financial Envelope'. The study findings suggest that the need for the ProjectCo to reduce costs to match the approved affordability limits established by the Public Sector Comparator (PSC) could result in low levels of sustainability innovation on BSF PFI projects. The limitations brought in by perceived capital cost risk is particularly damaging to SEI as the nature of the technology requires additional upfront cost and design time to develop energy-efficient buildings. Therefore, the limited acknowledgment of the need for such initial investment within BSF is potentially detrimental to SEI efforts.

b. Excessive perceived ***off-take*** and ***construction risks*** associated with the development of energy supply networks restricted their implementation on HGS (Case Study 3). O*ff-take risk* is that associated with understanding the demand for the heat load produced by the district heating network. This risk was difficult to manage due to the complex BSF engagement process. The competitive dialogue stage restricted the ability of ProjectCo actors to participate in discussions of sufficient detail with the 'local community' or providers to determine the feasibility and financial viability of delivering community schemes and energy networks. In addition, *construction risk* is that associated with the energy solution adopted failing to be delivered to agreed specification, schedule or budget. This risk was intensified by the difficulty of linking the timing of network provision and school construction. This meant that, if the system was to be adopted, it would be at the developer's risk, which is often unsupported by the ProjectCo's shareholders and funders. Risk was also exacerbated by the inflexibility of the BSF contract to allow for off-site energy generation and the involvement of Energy Supply Companies (ESCOs) to install, finance and deliver the network. Indeed, community-wide energy networks were seen to be difficult to implement through the BSF process. This is a missed opportunity in BSF as schools that are served by community heating schemes can be extremely carbon efficient, particularly where they are considered in the context of major local development, re-development or regeneration (Bartlett, 2008).

In conclusion, the study identifies that Proposition 5 is supported on the innovative projects. The SEIs implemented were supported on the innovative projects by the perceived *clarity, appropriateness* and *manageability* of energy-related risks on the BSF PFI contract. In fact, the main SEIs were largely developed in order to manage long-term energy performance risks allocated to ProjectCo actors and safeguard their long-term commitment to the project. However, the findings identified that excessive perceived innovation-related risks discouraged further SEI to be implemented. Particularly important are *capital cost risk* and *off-take and construction risks* associated with the development of energy supply networks.

10.2.6 Proposition 6: Findings

The study's sixth proposition advances that SEI is supported by incentive-based payments linked to the project's energy performance. The multiple case study findings, as outlined in Table F6 in Appendix F, however, identify that Proposition 6 is not supported across the case study projects. Two key findings can be drawn to explain why the proposition is not realised across the case study projects. The findings are presented under two headings: (1) Incentives on the standard BSF PFI Payment Mechanism, and (2) Introduction of additional incentives on the BSF PFI Payment Mechanism.

1. Incentives on the Standard BSF PFI Payment Mechanism

Financial mechanisms that enable the reward for innovation to be distributed according to the risk each party have assumed are seen as important determinants of CoPS innovation success (Hobday, 1998; Miller and Lessard, 2000). Key conceptual contributions also suggest that in order to encourage producers to achieve exceptional results in terms of certain performance criteria, incentive-based payment should be linked to specific aspects of project objectives (Bresnen and Marshall, 2000b; Tang *et al.*, 2006; Eriksson and Westerberg, 2010).

However, the multiple case study findings, as outlined in Box F6.1, indicate that the standard BSF PFI energy Payment Mechanism was seen to offer limited incentive for ProjectCo actors to thrive for continuous improvement of the project's energy performance. The BSF energy Payment Mechanism is structured with schools designed to specific energy consumption targets. A benchmarking exercise is scheduled to take place every three years on which the ProjectCo compares its prices for energy to the price of equivalents' service provision in the market. Subsequently, the corresponding part of the Unitary Payment is adjusted according to a pre-agreed formula. The ProjectCo can reap the benefit of any cost savings as a result of introducing energy-saving systems and strategies within the utility period before energy consumption is re-benchmarked. ProjectCo actors on BEC (Case Study 1), SVC (Case Study 2), and HGS (Case Study 3) unanimously agreed that this continuous re-benchmarking of energy consumption offers limited incentive for the ProjectCo to improve the energy performance of the building mid-contract. ProjectCo actors have limited incentive to introduce innovative energy-saving technologies as they become available in the market during the contract period because they will hardly reap any financial benefits from doing so before energy consumption is re-benchmarked. This is seen to be particularly problematic in the case of high-cost energy-saving technologies, with extended payback periods. The limited period within which ProjectCo actors can benefit from introducing the technologies before energy consumption is re-benchmarked discourages their implementation. While the ProjectCo will suffer a payment deduction if energy performance falls below the set performance targets, the ProjectCo will not receive sufficient additional payment if energy performance exceeds the performance targets. Therefore, the ProjectCo does not have an incentive, and, thus, is unlikely to improve energy performance beyond the minimum requirement mid-contract. This finding expands Hobday's (1998) and colleagues' view on the need for clients and producers to share the benefits of innovation by underlining the criticality of such mechanisms in long-term contracts. It suggests that contractual practices that do not support the *continuous* equitable distribution of the reward for improved energy performance among clients and producers offer limited incentive for producers to *continually* improve the facility's energy performance through innovation.

2. Introduction of Additional Incentives on the BSF PFI Payment Mechanism

While the standard BSF PFI Payment Mechanism was seen to offer limited incentive for continuous improvement of the project's energy performance, the case study findings identified that the introduction of additional incentives in the Payment Mechanism can work to remedy this deficiency. This was particularly the case on BWS (Case Study 4). On BWS (Case Study 4) the Local Authority bid for, and was successfully awarded the DCSF's additional funding of £50/m² to achieve the operational 27kg $CO_2/m^2/yr$ carbon target. The target was directly linked to the Payment Mechanism which dictated that should the facility emit more CO_2 during core hours; the ProjectCo was required to pay the first 10% increase in fuel costs, and 50% of any increase thereafter. Should the building be more efficient in operation, the ProjectCo reaps the full benefit of the first 10% under target and 50% of any additional savings. ProjectCo actors agreed that the operational carbon target and the incentives linked to achieving the target encouraged ProjectCo actors to achieve exceptional results for sustainable energy by implementing the innovative biodiesel CHP solution, the first of its kind in a UK school building. It also encourages ProjectCo actors to ensure that the building remains energy efficient by introducing innovative energy-saving technologies should they become available in the market during operation. The presence of such incentives allows the benefits of improvements to be shared among the ProjectCo and the Local Authority, thus supporting SEI efforts. Therefore, this case study finding suggests that in order to encourage private sector producers to continuously achieve exceptional results for sustainable energy, incentive-based payments should be linked to the sustainable energy performance of the building.

In conclusion, the study identifies that Proposition 6 is not supported across the case study projects. This was due to the absence of incentives in the standard BSF PFI Payment Mechanism to encourage ProjectCo actors to improve energy performance beyond the minimum requirement mid-contract. However, the case study findings also identify that the introduction of additional incentives in the Payment Mechanism linked to the project's energy performance exceeding set targets can work to encourage continuous improvement of the project's energy performance. The introduction of such mechanisms supports innovation by allowing the benefits of improvements to be shared among clients and producers.

10.3 Summary

The aim of this research study is to develop an understanding of the capacity of the PFI project delivery model to support the implementation of SEI on BSF new-build school buildings. This Chapter discussed the extent to which six conceptual propositions have translated into experienced reality in supporting the implementation of SEI during the design development stages of the case study projects. The main case study findings are as follows:

1. The proposed relationship between the clarity of the sustainable energy requirement in the BSF PFI delivery model and the SEI outcome was not realised across the case study projects. *Clarity of the sustainable energy requirement* was weakened across the case studies by its limited 'specificity' and 'achievability'. While *clarity of the governing framework* was achieved on BSF documentation, several deficiencies in the framework dampened ProjectCo actors' incentive to pursue SEI. Particularly detrimental were the inability of BREEAM to promote energy efficiency, the rigid design standards that the design needed to adhere to, and the low weighting of sustainability and energy issues on BSF bid evaluation criteria.

2. The proposed relationship between multidisciplinary communication and collaboration in the BSF PFI delivery model and the SEI outcome was not realised. *Open communication* among design, construction and operation disciplines was weakened on the case study projects by lack of integration of Facility Management into influencing design decisions.

Effective collaboration was weakened by misalignment of objectives among architects, contractors, and facility managers. While Architect-Building Contractor relationships were increasingly challenging across the four case studies, alignment of Building Contractor-Facility Manager objectives was shaped by the ProjectCo composition, and the introduction of joint operational energy objectives that align their interests towards SEI.

3. The proposed relationship between Client-Producer communication and collaboration in the BSF PFI delivery model and the SEI outcome was not realised. *Open communication* was weakened across the four case studies by the restrictive nature of the BSF engagement process. The process involved a multitude of issues and therefore it pushed environmental sustainability and energy issues further down the priority list. While *effective collaboration* drove SEI on two of the innovative projects, this was often interrupted by misalignment of objectives between the ProjectCo and the Local Authority, the restricted Architect-Local Authority relationship, and the competitive nature of BSF engagement processes.

4. The proposed relationship between User-Producer communication and collaboration in the BSF PFI delivery model and the SEI outcome was not realised. *Open communication* was restricted by the 'formal', 'cold', 'rigid' and 'very difficult' nature of BSF engagement processes. *Effective collaboration* was also weakened by the schools' limited responsibility over the energy performance of their building under the PFI contract, resulting in sustainability and energy efficiency issues being further down their priority list.

5. The proposed relationship between risk allocation in the BSF PFI delivery model and the SEI outcome was realised on the innovative projects. The SEIs implemented were supported on the innovative projects by the perceived *clarity, appropriateness* and *manageability* of energy-related risks on the BSF PFI contract. In fact, the SEIs were largely developed in order to manage long-term energy performance risks allocated to ProjectCo actors and safeguard their long-term commitment to the project. However, the findings identified that excessive perceived innovation-related risks discouraged further SEI to be implemented. Particularly important are capital cost risk, and off-take and construction risks associated with the development of energy supply networks.

6. The proposed relationship between reward sharing mechanisms in the BSF PFI delivery model and the SEI outcome was not realised on three of the case study projects. This was

due to the absence of incentives in the standard BSF PFI Payment Mechanism to encourage ProjectCo actors to improve energy performance beyond the minimum requirement mid-contract.

Chapter 11- Conclusion

11.1 Introduction

This Chapter presents the conclusions drawn from the research study and the recommendations based on those conclusions. First, the Chapter provides an overview outlining the research questions, objectives and the strategy adopted to pursue them. Second, it presents the main conclusions drawn from the research findings. Third, it outlines the recommendations developed on how both the public and private sector actors on BSF PFI projects can support the implementation of Sustainable Energy Innovation (SEI) subject to their respective constraints. Fourth, the limitations of the study are highlighted. Fifth, the Chapter highlights the contribution to knowledge that this research makes. Finally, the Chapter presents recommendations for future research agenda on the implementation of SEI on PFI projects.

11.2 Research Overview

There are growing calls around the Globe for sustainability and energy efficiency. Meeting the formidable challenges associated with climate change will demand substantial technical progress to deliver more sustainable energy solutions for societal needs. The public sector, as a major construction industry client, can play a significant role in promoting innovation in both products and services. Indeed, the Confederation of British Industry (CBI, 2006) argues that 'public procurement is the biggest single customer-side driver that could be harnessed to catalyse business innovation activity' (p. 2).

A major UK public procurement programme was Building Schools for the Future (BSF). BSF was an immensely ambitious programme designed to rebuild or refurbish all secondary schools in England over 15 years at a cost of £45 billion. It was the most comprehensive of a number of initiatives to improve the school's estate that the government has introduced since 1997. As well as being a project to improve radically the fabric of school buildings and transform the educational experiences of pupils, it has been actively seeking to embed sustainability (PfS, 2007). Wilkinson (2008) argues:

> The biggest school building programme in a generation presents a unique opportunity to incorporate sustainability into the very DNA of our schools (Wilkinson, 2008, p. 1).

The government's preferred delivery model for new-build BSF schools was the Private Finance Initiative (PFI), a type of Public Private Partnership (PPP). The introduction of PFI into the government's BSF procurement policy was fundamentally driven by the desire to improve project performance including lower project costs, shorter construction times, and higher overall quality in the end product. It is also widely advocated that PFI projects will bring about innovation by engineering unique cooperative arrangements between clients, designers, constructors and operators (Leiringer, 2003). These cooperative arrangements in conjunction with added incentives and long-term commitments are seen to ultimately lead to innovative solutions to the public sector client's service requirements (Leiringer, 2003). This innovative capacity of the PFI project arrangement is nowhere more needed than in meeting global pressures for environmental transformation and sustainable development (Malmborg, 2007). Indeed, many commentators stress the importance of inter-organisational partnerships and networks in the future of environmental policy and management (Hartman *et al.*, 1999; Roome, 2001; De Bruijn and Tukker 2002; Malmborg, 2007).

However, whether the PFI delivery model delivers its promises as an arena for sustainability and environmental innovation is still to be determined. While the capacity of PPP/PFI project models to encourage innovation is widely accepted in the construction industry, the theoretical basis to support those claims is largely underdeveloped. In fact, Leiringer (2003) goes as far as to contest that several publications that endorse PPP/PFIs as vehicles for innovation are mostly based on anecdotal evidence and wishful thinking. This theoretical and empirical gap becomes even greater when examining the capacity of PPP/PFI project models to support innovation for environmental sustainability. The literature review conducted as part of this research study could not identify any previous research that explored the relationship between PPP/PFI project models and innovation for environmental sustainability, including SEI. This is a significant gap in knowledge, considering the importance of the subject. Therefore, this research study sought to expand previous PFI innovation research, such as that of Leiringer (2003, 2006) and Barlow and Köberle-Gaiser (2008ab), by improving understanding of the implementation of SEI within BSF PFI projects. By doing so, the study may lead to a greater awareness of how 'New Public Procurement Models' (Pryke, 2001; Barlow and Köberle-Gaiser, 2008) should work to encourage sustainable products and services (Erdmenger, 2003). Therefore, the following two research questions were forwarded:

> **Question 1: What is the capacity of the PFI project delivery model to support the implementation of SEI on BSF new-build school projects?**

> **Question 2: How can SEI be supported within the BSF PFI project delivery model?**

On this research study, the implementation of SEI in the PFI delivery model is seen to be particularly problematic due to the need for effective inter-organisational interactions in the development of such innovations. Scholars such as Rohracher (2001), Ornetzeder and Rohracher (2006) and Heiskanen and Lovio (2007) underline the increasing levels of functional dependency and components complexity associated with the development of environmental innovations. Therefore, these innovations can only be successfully developed through closer interaction among producers, clients, and users (Rohracher, 2001). Thus, following previous studies such as those of Barlow and Köberle-Gaiser (2008ab) and Caldwell *et al.* (2009) the BSF PFI project is conceptualised as a Complex Product Systems (CoPS) supply network (Hobday, 1998) where innovation success largely depends on the interactive relationships among multiple project participants (Hobday, 1998, 2000; Hobday *et al.*, 2000; Gann and Salter, 2000; Davies and Salter, 2006). Hence, in order to examine the relationship between the PFI project model and SEI, it is necessary to consider the interactions between the different organisations involved in BSF PFI project developments. Following the explanation of the study's key assumptions, and in order to adequately address the research issues, the two research questions are translated into five research objectives:

> **Objective 1: To identify key determinants of SEI postulated in CoPS Innovation Management Theory.**

Objective 2: To identify key characteristics of the PFI project delivery model within the context of BSF new-build school projects.

Objective 3: To develop a conceptual framework to examine the capacity of the PFI project delivery model to support the implementation of SEI based on innovation determinants postulated in CoPS Innovation Management Theory.

Objective 4: To examine the capacity of the PFI project delivery model to support the implementation of SEI based on the developed conceptual framework.

Objective 5: To propose potential solutions to the problematic issues identified in the implementation of SEI within BSF PFI projects.

In order to fulfil the stated research questions and objectives, the study followed a six-stage research development process as follows:

Stage 1: The first stage included extensive literature review on innovation examining leading academic and technical journals, technical reports, text books, case studies and government guidelines and reports. The output of this stage formed Chapter 2 of this report. A theoretical description of key determinants of SEI was developed, based largely on a thorough review of mainstream, CoPS as well as construction-specific innovation literature. One of the fundamental points of departure for this study is the understanding of innovation as 'the actual use of a nontrivial change in a process, product or system that is novel to the institution developing the change' (Freeman, 1989, p. 11). The study also adopts a Complex Product Systems (CoPS) perspective to SEI where innovation success largely depends on the dynamic, collective and interactive relationships among multiple project participants (Hobday, 1998, 2000; Hobday *et al.*, 2000; Gann and Salter, 2000; Davies and Salter, 2006). Particularly, and following from this conceptualisation is the view that innovation activities need to be understood in terms of an interactive relationship between the Client/User and the Producer, and within the Producer's supply chain. The Chapter outlined three project-level determinants of CoPS innovation, focusing on those where interaction among project participants is considered to be of particular importance. First, in CoPS projects, innovation success largely depends on the greater *clarity of the client requirements* (Hansen and Rush, 1998). Indeed, Hansen and Rush (1998) and Hobday and Rush (1999) underlined the importance of greater clarity of the client requirement in their study of 'hotspots' often confronted by firms producing CoPS. Second, many studies of CoPS have highlighted the importance of effective *communication and collaboration* for successful innovation (Miller *et al.*, 1995; Hobday, 2000; Brady *et al.*, 2005). In CoPS projects, multidisciplinary communication and collaboration is needed and non-functional organisational structures are necessary to co-ordinate production (Hobday *et al.*, 2000). The importance of effective Client/User-Producer communication and collaboration for successful innovation was also identified by several studies in CoPS innovation (Miller *et al.*, 1995; Hobday, 1998). End users in CoPS projects are often well integrated into the innovation process, as products are tailored to fit their requirements (Hobday, 1998). Third, *contractual incentives,* particularly risk and reward sharing arrangements, whereby the benefits from innovation and performance improvement are shared between project participants are seen as key innovation drivers (Hobday, 1998).

Attention was then focused on the project-based construction industry and the three determinants of CoPS innovation were explored. First, *the client requirement* is seen as an important driver for SEI in construction projects. Sustainability innovation is often stimulated by clients' recognising the need for innovation through challenging sustainability, engineering, construction, and schedule requirements (Anderson *et al.*, 2004; Bossink, 2004; Richardson and Lynes, 2007). Second, *communication and collaboration* is particularly important for sustainable buildings, as high level of expertise is needed to deal with the complex problems of environmental design (Rohracher, 2001; Anderson *et al.*, 2004; Intrachooto and Horayangkura, 2007). Client/User-Producer communication and collaboration is also seen to be critical in achieving sustainable energy objectives and reducing CO_2 emissions (Ornetzeder and Rohracher, 2006; Heiskanen and Lovio, 2007). Third, *contractual incentives* are needed for environmental innovation due to the high levels of uncertainty and risk associated with the development of such technologies (Bossink, 2004; Intrachooto and Horayangkura, 2007). In conclusion, this theoretical legacy, combining different but complementary theoretical views from CoPS Innovation Management Theory, as well as construction-specific innovation studies, indicate that a CoPS approach is particularly useful for understanding the innovative capacity of the PFI project delivery model. Synthesis of these theoretical contributions emphasised the importance of three project-level determinants for SEI success:

1. Clarity of the requirement (Hansen and Rush, 1998; Hobday and Rush, 1999; Ren and Yeo, 2006).

2. Communication and collaboration:
    i. Producers' multidisciplinary communication and collaboration (Miller *et al.*, 1995; Hobday, 2000; Brady *et al.*, 2005).
    ii. Client-Producer communication and collaboration (Gardiner and Rothwell, 1985; Miller *et al.*, 1995; Hobday, 1998).
    iii. User-Producer communication and collaboration (Hobday, 1998; von Hippel, 1988; 1998; Lundvall, 1988).
3. Contractual incentives:
    i. Risk allocation (Hobday, 1998; Miller and Lessard, 2000).
    ii. Reward-sharing mechanisms (Hobday, 1998; Miller and Lessard, 2000).

This first stage provided the information needed to fulfil **Objective 1** by identifying key determinants of SEI postulated in CoPS Innovation Management Theory.

Stage 2: The second stage involved a thorough review of the literature on PPP, PFI and BSF Projects. The literature review examined refereed academic and technical journals, technical reports, manuals, conference proceedings, case studies, business and financial press, and official government reports and guidelines. The output of this stage formed Chapter 3 of this report. The Chapter started by introducing PFI as a form of Public Private Partnership (PPP) and PPPs were defined and the motivation for their adoption explained. The next step was to examine the contractual actors involved and main development stages. Finally, key characteristics of the PFI project delivery model that differentiate this procurement strategy from traditional procurement are presented. These characteristics are particularly important as they create the distinct BSF PFI environment in which private sector actors operate and innovate. Attention was first focused on the nature of the BSF PFI Output Specification. Second, BSF PFI engagement processes were explained. Third, three characteristics of the BSF PFI contract were highlighted, specifically ProjectCo Integration under the DBFO contract, BSF PFI risk allocation and the BSF PFI Payment Mechanism. The Chapter concluded by advancing that these key characteristics of the BSF PFI delivery model are of particular importance to the implementation of SEI and should be considered as part of the explanation of the phenomenon.

This second stage provided the information needed to fulfil **Objective 2** by identifying the key characteristics of the BSF PFI delivery model that differentiate this procurement strategy from more traditional approaches.

Stage 3: The third stage sought to ascertain current practice and increase the understanding of key actors' motivation for entering into BSF PFI projects and their objectives and expectations in terms of environmental sustainability and energy efficiency. This stage involved 15 semi-structured interviews with senior representatives of both public and private organisations involved in BSF development. Appendix B provides a list of introductory interview participants. This helped to streamline the study through the identification of core areas of interest.

Stage 4: The fourth stage utilised the literature review from Stages 1 and 2 together with the insights gained from the introductory interviews in Stage 3 to build a conceptual framework to examine the capacity of the BSF PFI delivery model to support the implementation of SEI. The output of this stage constituted Chapter 4 of this report. Each determinant of CoPS innovation success identified in Chapter 2 is explored in more detail in this conceptual Chapter and six research propositions are developed. The proposed causal relationships are based on CoPS Innovation Management Theory, and supported by related studies of New Product Development, and construction innovation. The six research propositions are as follows:

> **Proposition 1:** SEI is supported by the greater clarity of the sustainable energy requirement and governing framework on the BSF PFI Output Specification.
>
> **Proposition 2:** SEI is supported by open communication and effective collaboration within the integrated ProjectCo, particularly among design, construction, and operation disciplines.
>
> **Proposition 3:** SEI is supported by open communication and effective collaboration during BSF Local Authority-ProjectCo engagement processes.
>
> **Proposition 4:** SEI is supported by open communication and effective collaboration during BSF School-ProjectCo engagement processes.
>
> **Proposition 5:** SEI is supported by clear, appropriate and manageable allocation of the risks associated with the project's energy performance.

Proposition 6: SEI is supported by incentive-based payments linked to the project's energy performance.

Stages 3 and 4 fulfilled **Objective 3** by developing a conceptual framework to examine the capacity of the PFI project delivery model to support the implementation of SEI based on innovation determinants postulated in CoPS Innovation Management Theory.

Stage 5: The fifth stage presented a research strategy to test the conceptual framework and research propositions developed in Stage 4. The research strategy guided the process through which detailed fieldwork was undertaken, an extensive amount of data collected, in-depth analysis conducted and testing of emergent findings carried out. A qualitative approach was considered the best-suited for this research, given the exploratory nature of the study. Therefore, a qualitative multiple case study research strategy was adopted, based on replication logic. Four case studies were selected following set criteria to ensure comparability and to maximise what could be learned from the study. Three case studies were selected on the grounds that they showed at least one significant SEI, and one case study was selected on the grounds that it showed no evidence of SEI. The three innovative projects were Brislington Enterprise College-Bristol City Council (Case Study 1), Highbury Grove School-London Borough of Islington (Case Study 2) and Big Wood School-Nottingham City Council (Case Study 4). The project that showed no evidence of innovation was Soar Valley College-Leicester City Council (Case Study 2). Data was collected through semi-structured interviews with ProjectCo, Local Authority and School representatives from each case study. This ensured triangulation of the data collected and improved its validity. In total, 50 interviews were conducted. Data collection also involved extensive review of BSF and project-specific documentation. A Case Study Interview Protocol was developed to guide the interview process and qualitatively measure the study's main conceptual constructs. Literal replication was sought on the three innovative projects, while theoretical replication was sought on the fourth. The output of this multiple case study research strategy formed chapters 5–11 of this report.

Stage 5 fulfilled **Objective 4** by utilising case studies to examine the capacity of the BSF PFI project delivery model to support the implementation of SEI. It involved conducting in-depth analysis of data collected from the multiple case studies and identifying the extent to which the six conceptual propositions developed in Chapter 4 were supported. The findings also outlined the problematic issues confronted by firms pursuing SEI on BSF PFI projects.

Stage 6: The sixth stage involved examining the problematic issues identified in the implementation of SEI and developing solutions to remedy their effect. This was pursued by using theoretical and a priori reasoning which builds on the findings from all previous stages. The output of this stage forms section 11.4 of this Chapter.

Stage 6 fulfilled **Objective 5** by proposing potential solutions to the problematic issues identified in the implementation of SEI within the BSF PFI delivery model. Ultimately, the findings from the six-stage research development process fulfilled the two research questions and five research objectives.

11.3 Concluding Discussion

The aim of this research study was to examine the capacity of the PFI project delivery model to support the implementation of SEI within the context of the UK government's BSF Programme. Adopting CoPS Innovation Management Theory (Hobday, 1998) we have argued that innovation for sustainable energy on BSF PFI projects cannot be understood as an isolated decision-making process undertaken by one firm. Rather, SEI should be understood as a multidisciplinary activity spanning multiple organisations and circumstances. The BSF PFI project was conceptualised as a CoPS supply network (Hobday, 1998) where success in innovation largely depends on the collective, dynamic and interactive relationships among multiple project participants (Hobday, 1998, 2000; Hobday *et al.*, 2000; Gann and Salter, 2000; Davies and Salter, 2006). Particularly, and following from this conceptualisation, was the view that SEI needs to be understood in terms of an interactive relationship among the public sector Client/User and the private sector Producer, and within the Producer's supply chain. In the case of BSF PFI projects, the public *Client* is represented by the Local Authority, the principal client for all building, ICT, and facilities contracts while the public *User* is the School, the ultimate user of the new facility. The private *Producer*, on the other hand, is ultimately the ProjectCo; the group of private sector actors who come together to bid for and later to implement the PFI project. Taking such a system-oriented perspective is particularly important for SEI due to the increasing levels of functional dependency and component complexity in sustainable buildings. Thus, effective interaction among producers, clients and users is seen to be critical for their successful development (Rohracher, 2001; Intrachooto and Horayangkura, 2007). Based on three key determinants of CoPS innovation success, a conceptual framework was developed in Chapter 4 that underlines the importance of such inter-organisational interaction in shaping the process of innovation. It draws together substantial previous research into one coherent framework that was used to examine the capacity of the PFI delivery model to support SEI on BSF new-build school projects. The following determinants of CoPS innovation success were seen to be of particular importance to understanding SEI and should be considered as part of the explanation of the phenomenon:

1. Clarity of the requirement (Hansen and Rush, 1998; Hobday and Rush, 1999; Ren and Yeo, 2006).
2. Communication and collaboration:
   i. Producers' multidisciplinary communication and collaboration (Miller *et al.*, 1995; Hobday, 2000; Brady *et al.*, 2005).
   ii. Client-Producer communication and collaboration (Gardiner and Rothwell, 1985; Miller *et al.*, 1995; Hobday, 1998).
   iii. User-Producer communication and collaboration (Hobday, 1998; von Hippel, 1988; 1998; Lundvall, 1988).
3. Contractual incentives:
   i. Risk allocation (Hobday, 1998; Miller and Lessard, 2000).
   ii. Reward-sharing mechanisms (Hobday, 1998; Miller and Lessard, 2000).

Six conceptual propositions were subsequently developed in Chapter 4 and were used as templates for data collection and analysis. Following a four-case qualitative research methodology, the empirical findings point to the significance of the three determinants of CoPS innovation in shaping the environment in which private sector producers operate and innovate in BSF PFI projects. The interplay between the three CoPS determinants shaped the process of innovation and the SEI implemented on the case study projects. However, while the qualitative nature of the chosen research methodology limits the ability to generalise, the following case study findings provide empirical evidence to the limited capacity of the PFI delivery model to support SEI based on the key determinants of innovation postulated in CoPS Innovation Management Theory:

1. ***Clarity of the Requirement***: Proposition 1 examined the relationship between the clarity of the sustainable energy requirement in the BSF PFI delivery model and the SEI outcome. Indeed, In CoPS projects, innovation success largely depends on how well the clients can define their requirements (Hobday, 1998; Hansen and Rush, 1998; Hobday and Rush, 1999). Hansen and Rush (1998) and Hobday and Rush (1999) underlined the importance of greater

clarity of the client requirement in their study of 'hotspots' often faced by CoPS producers. However, Proposition 1 was not supported across the innovative BSF PFI projects studied. In fact, Proposition 1 findings suggest that clarity of the sustainable energy requirement on BSF PFI projects is often weak, particularly in relation to its limited 'specificity' and 'achievability' (Case Studies 1, 2 and 3). First, the research findings underline an important dimension of a requirement's 'specificity', and that is its sensitivity to its particular context. Limited specificity on two of the innovative projects (Case Studies 1 and 3) resulted from the Local Authorities' provision of a general requirement to 'reduce energy consumption', lack of site-specific targets for carbon reduction or on-site renewable energy generation, and the large amount of information included in the Output Specification. While it is often argued in the theory of PFI that output-based requirements support innovation by the greater flexibility and design freedom provided to producers (Heavisides and Price, 2001; Leiringer, 2006) the research findings, however, suggest that these espoused innovation benefits were negated at times by the requirement's limited specificity. This left sustainability open to interpretation and somewhat compromised (Case Studies 1 and 3). Indeed, the findings suggest that output-based requirements may not satisfy the context-sensitive nature of sustainability.

Second, Proposition 1 findings also suggest that 'achievability' of a sustainability requirement is an important dimension of its clarity and can be characterised by its sensitivity to existing technological and financial constraints. Achievability concerns pertaining to the sustainable energy requirement, such as the requirement for zero-carbon schools (Case Study 2) and the change to a challenging requirement midway through the design process (Case Study 3), were found to exert significant pressure on private sector producers and restrict the innovative interpretation of the requirement. This case study finding contradicts previous innovation management research, which argues that policymakers can encourage private sector producers to develop new ideas by imposing challenging requirements that are difficult for existing technologies to conform to, thus inducing innovation, e.g. Seaden and Manseau (2001) and Blayse and Manley (2004). In fact, the study findings demonstrate that such mechanisms should be implemented with caution, particularly in relation to current technological and financial constraints. Limited achievability of the sustainable energy requirement increases the pressure on private sector producers (Case Study 3) and dampens incentives for innovation (Case Study 2). Indeed, Case Study 4 findings, in which the challenging 27kg $CO_2/m^2/yr$ requirement coupled with the additional funding of £50/m² encouraged the innovative biodiesel CHP solution, the first of its kind in a UK School building, suggest that for such mechanisms to be effective in supporting SEI, alignment of the innovative requirement with the allocated budget is necessary.

Proposition 1 findings also identify that while clarity of the governing framework, in terms of regulation, standards and norms, could be achieved in PFI documentation, several deficiencies in the framework itself may dampen producers' incentive to pursue SEI. Particularly detrimental across the case study projects were the inability of the BREEAM requirement to promote energy efficiency (Case Studies 1–4), the rigid design standards that the design needed to adhere to (Case Study 3) and the low weighting of the sustainable energy requirement in BSF bid evaluation criteria (Case Studies 1–4). In fact, the pursuit of SEI on the innovative projects (Case Studies 1, 3 and 4) was not particularly driven by the weighting of the sustainability requirement in bid evaluation, but by the view of sustainability as a competitive strategy to differentiate private sector producers' bids and a marketing strategy to strengthen their environmental credentials. This observed perception of SEI as a competitive strategy may resonate more with linear Schumpeterian models of innovation, particularly the market-pull model. In such a model, environmental innovation is seen to originate from corporate investment in response to market forces (OECD, 2008) such as competitiveness (Sarkis, 1995; Henriques and Sadorsky, 1996) and green consumerism (Elkington, 1994; Drumwright, 1994; Howes *et al.*, 1997). Across the case study projects, sustainability and being known for having a 'green brand' were seen as necessary for these companies' survival. Indeed, the competitive nature of the BSF design process worked to encourage sustainability innovation, as a differentiating strategy by contractors. Thus, it can be argued that it was not the greater clarity of the client sustainability requirement, but the market-pull drivers of competiveness and recognising the client interest in sustainability that supported the SEI outcome.

2. ***Producers' Multidisciplinary Communication and Collaboration***: Proposition 2 explored the relationship between multidisciplinary communication and collaboration in the BSF PFI delivery model and the SEI outcome. Certainly, the importance of multidisciplinary communication and collaboration for successful innovation was highlighted by many studies of CoPS innovation (Miller *et al.*, 1995; Hobday, 2000; Brady *et al.*, 2005). In CoPS projects, a wide breadth of knowledge and skills are needed, thus, producers' main tasks are system

integration and the management of multidisciplinary networks in temporary projects (Hobday, 1998). However, Proposition 2 was not supported across the innovative BSF PFI projects studied. In fact, Proposition 2 findings indicate that multidisciplinary communication and collaboration towards SEI, particularly among design, construction and operation disciplines, are often not attainable in BSF PFI projects. While it is argued in the theory of PFI that it is in the interest of the ProjectCo to ensure that the objectives of architects and contractors are aligned and that they are working collaboratively (Davies and Salter, 2006; Carrillo *et al.*, 2006) the research findings, however, demonstrate that this is seldom achievable. In fact, there was an apparent conflict of sustainability objectives among architects and contractors and relationships between the two were challenging across the four case study projects. Conflict of interest often resulted from architects' desire to achieve exceptional results for sustainability and the limited budget available to building contractors. Contractors were seen to settle for meeting the minimum environmental requirements with the least cost. Under the D&B contract, architects felt 'controlled', 'restricted' and driven to 'tokenistic' strategies by contractors. The balance of power on BSF PFI contractual structure is in favour of contractors and leaves architects in a position where key sustainability decisions are controlled by contractors. This complicates efforts to introduce SEI as it significantly constrains the innovative capacity of architects (Case Studies 1–4). The contractor-led D&B contract also increases the distance between architects and Local Authorities, restricting the opportunity to build close Architect-Local Authority relationships and weakening the ability of the design to develop and mature (Case Studies 1, 2 and 3).

In addition, the structure of contractual relationships in the BSF PFI delivery model was also found to weaken Design/Construction-Operation communication and collaboration towards SEI. It is often maintained in the theory of PFI that the ProjectCo assuming design, construction and operational responsibility for the fixed capital asset is an incentive for the ProjectCo to consider the implication of design and construction decisions on the long-term operational performance of their asset (Davies and Salter, 2006; Robinson and Scott, 2008). This is seen to strengthen Design-Construction-Operation communication and collaboration, ultimately supporting innovation efforts (Davies and Salter, 2006; Robinson and Scott, 2008). However, Proposition 2 findings identify that these espoused benefits may not translate into experienced reality in BSF PFI projects. Across the four case studies, Design-Operation communication was restricted by the use of separate D&B and operational contracts, which increases the distance between design teams and facility managers and disconnects incentives to implement energy-efficient technologies from opportunities to do so. In fact, facility managers across the case study projects were increasingly frustrated in suboptimal design solutions implemented by design teams without consultation with facility managers (Case Studies 1, 2 and 4). The reluctance of the ProjectCo SPV, as the System Integrator (Barlow and Köberle-Gaiser, 2008b), to commit large resources into the bidding stage, due to the risks involved, also meant that facility managers had a limited degree of involvement during the bidding phase and their input post-bidding was restricted to maintenance issues (Case Studies 1–4).

Moreover, Construction-Operation collaboration was weakened by the separation of companies responsible for construction and those responsible for operation (Case Study 2). As the building contractors carry no operational risk, they are not incentivised to improve the energy performance of the building beyond the minimum requirements. Innovative energy solutions which are likely to result in increased initial capital cost to the Building Contractor are, thus, not welcomed. Indeed, Proposition 2 findings suggest that alignment of sustainable energy objectives among construction and operation disciplines is influenced by two factors; being the ProjectCo composition (Case Studies 1, 3 and 4) and the introduction of joint Building Contractor-Facility Manager operational energy responsibilities (Case Study 4). First, the innovative projects (Case Studies 1, 3 and 4) were delivered by integrated service companies, as opposed to the project where no innovation was implemented (Case Study 2). ProjectCo actors on the three innovative projects unanimously agreed that the ability of their company to deliver integrated services of design, construction, and operation was an incentive for the bid team to thrive for the best possible energy solution because ultimately they are responsible for the energy charge. Second, in BWS (Case Study 4) incentives to improve the operational energy performance of the building were supported by the introduction of the operational carbon target of 27kg $CO_2/m^2/yr$ and placing this obligation on the Building Contractor. As the Building Contractor was legally liable and financially responsible for any rectification needed for the building to meet this target, they were incentivised to take the operational energy performance of the building into consideration. By including specific energy success criteria in joint objectives, both the Building Contractor and Facility Manager explicitly declared that these aspects are important, which in turn aligned their objectives towards SEI. Contradicting established positions on the innovation benefits of ProjectCo integration (HM Treasury, 2000b, 2003; Domberger and Jensen, 1997; Davies and Salter, 2006); the research findings indicate that

ProjectCo integration on the BSF PFI delivery model does not necessarily facilitate open communication and effective collaboration among design, construction, and operation disciplines. It certainly does not ensure that the sustainable energy objectives of architects, contractors and facility managers are aligned and that they are working collaboratively towards SEI.

3. ***Client-Producer Communication and Collaboration:*** Proposition 3 focused on the relationship between Client-Producer communication and collaboration in the BSF PFI delivery model and the SEI outcome. Certainly, Client-Producer communication and collaboration is critical for CoPS innovation success (Hobday, 1998; Gardiner and Rothwell, 1985). However, Proposition 3 was not supported across the innovative BSF PFI projects studied. In fact, Propositions 3 findings identify that Client-Producer communication and collaboration towards SEI is often weak in BSF PFI projects, particularly in relation to the restrictive nature of BSF engagement processes, and the misalignment of their project objectives and priorities. Indeed, highly formalised engagement procedures, particularly those monitored by governmental bodies such as in BSF, complicate Client-Producer communication and restrict the ability of producers to clearly identify client's sustainability requirements and fit the design to their particular needs (Case Studies 1–4). In addition, the competitive nature of the design process results in producer's reluctance to propose innovative solutions or invest in high-cost energy model whilst bidding due to the risks involved. It also raises concerns that sustainability promises made during the bid could be compromised by affordability considerations post-bidding. The limited time allocated to the design process may also result in poor quality design and the pursuit of the building's aesthetical quality rather than its sustainability.

   While Proposition 3 findings identified that effective dialogue among ProjectCo and Local Authority actors did take place on the innovative projects (Case Studies 1, 3 and 4) and was instrumental in clarifying the sustainable energy requirement, this was, however, achieved despite the *restrictive* BSF process rather than being *supported* by the process. Indeed, Local Authority Core Teams on the innovative projects were faced with many challenges to allow such sustainability discussion to take place. Communication was difficult because it needed to be equal and uniform across all bidders. The magnitude of stakeholders involved during the engagement process and confidentiality issues highly complicated communication. The BSF process was seen to be prescriptive and involved many issues, and thus it pushed sustainable energy down the priority list. Effective dialogue was only possible through active Local Authority-ProjectCo interface management by key boundary spanners and sustainability champions (Case Studies 1, 3 and 4). It was also reinforced on two of the innovative projects by the Local Authority 'Readiness to Deliver Sustainability'. Indeed, supporting arguments in the literature on the need for greater client's competence and understand of their objectives (Reich *et al.*, 1996; Tatum, 1997; Barrett and Stanley, 1999; Ive, 1996), the findings emphasise its importance in sustainable innovation processes. The findings suggest that it was the client's 'Readiness to Deliver Sustainability', in terms of competence, understanding of their sustainability requirements, and determination to pursue a specific sustainable energy objective, one that defines and demands innovation, that was particularly important for SEI (Case Studies 3 and 4).

However, effective Client-Producer collaboration on two of the innovative projects (Case Studies 1 and 3) was interrupted by misalignment of objectives among Local Authority and ProjectCo actors, particularly in relation to the trade-off between the Local Authority's sustainability aspirations and the limited BSF budget allocated. While alignment of objectives among project participants is considered one of the essential conditions for implementing innovation (Hobday, 1998; Dulaimi *et al.*, 2003) as, however, the case study findings indicate, this is often not attainable. There remain conflicts of interest among the public sector client and private sector producer that restrict the development of collaborative relationships towards SEI. We conclude that, while Client-Producer communication and collaboration is seen to be important for CoPS innovation success (Hobday, 1998; Gardiner and Rothwell, 1985), the restrictive nature of BSF engagement processes, and the misalignment of Client-Producer project objectives and priorities weaken the capacity of such determinant to support SEI in the BSF PFI delivery model.

4. ***User-Producer Communication and Collaboration:*** Proposition 4 examined the relationship between User-Producer communication and collaboration in the BSF PFI delivery model and the SEI outcome. User-Producer communication and collaboration is necessary for CoPS innovation as products are tailored to fit users' requirements (Hobday, 1998). However, Proposition 4 was not supported across the innovative BSF PFI projects studied. In fact, Proposition 4 findings indicate that User-Producer communication and collaboration is often not achievable on BSF PFI projects due to the restricted nature of their engagement processes and the misalignment of their sustainability objectives under the PFI contract.

First, User-Producer communication was restricted by the highly formalised BSF engagement processes, which lack adequate appreciation of the long-term benefits of engaging with users in expressing their sustainability aspirations and building their awareness. Second, the structure of User-Producer contractual relationships in the BSF PFI delivery model may equally fail to support effective collaboration towards SEI. Across the four case study projects, joint School-ProjectCo collaboration was found to be weakened by the nature of the BSF PFI contract, which removes the responsibility of the facility's energy performance from schools. As PFI Schools, the building is managed by an Operator who oversees all aspects of its performance, including its energy performance. This resulted in sustainability and energy efficiency issues being further down schools' priority list. Schools' priority was fundamentally their educational requirements and achieving transformational learning environments to their pupils. These design aspirations, however, often contradicted the energy efficiency objective. Innovation management theorists, such as von Hippel (1988), maintain that users' incentive to engage in innovative activities rest on their ability to benefit from the results of the innovation (von Hippel, 1988). The research findings support this view and offer further explanation to users' incentives to collaborate in sustainable innovation processes. Particularly, the research findings suggest that contractual User-Producer relationships may strongly define these espoused innovation benefits. The research findings indicate that contractual practices that remove the responsibility of the facility's energy performance from the user offer limited incentive for the user to consider the operational energy performance of the building as their main concern. It follows that, while User-Producer communication and collaboration is necessary for CoPS innovation success (Hobday, 1998), the restricted nature of User-Producer engagement processes and the misalignment of their sustainability objectives under the PFI contract weaken the capacity of such a determinant to support SEI in the BSF PFI delivery model.

5. ***Reward-Sharing Mechanisms****:* Proposition 6 focused on the relationship between reward-sharing mechanisms in the BSF PFI delivery model and the SEI outcome. Indeed, contractual incentives are seen as important determinants of innovation in CoPS projects (Hobday, 1998; Miller and Lessard, 2000). Previous studies, such as Hobday (1998) and Miller and Lessard (2000), emphasise the need for clients and users of CoPS to share the rewards of innovation with producers. However, Proposition 6 was not supported across the innovative BSF PFI projects studied. In fact, Proposition 6 findings identified that such determinants of innovation are weak in the BSF PFI delivery model, particularly in relation to the BSF PFI

Payment Mechanism. On two of the innovative projects studied (Case Studies 1 and 3), as well as the project where no innovation was implemented (Case Study 2), the capacity of the standard BSF PFI Payment Mechanism to support the implement of SEI mid-contract was weakened by the continuous benchmarking of energy consumption scheduled to take place every three years. This is seen to be particularly problematic in the case of high-cost technologies with extended payback periods. The limited three-year period within which ProjectCo actors can benefit from introducing the technologies before energy consumption is re-benchmarked discourages their implementation. While the ProjectCo will suffer a payment deduction if energy performance falls below the set performance targets, the ProjectCo will not receive sufficient additional payment if energy performance exceeded the performance targets. Therefore, the ProjectCo does not have an incentive, and thus is unlikely to improve energy performance beyond the minimum requirement mid-contract. This finding expands Hobday's (1998) and colleagues view on the need for the client and producer to share the benefits of innovation by underlining the criticality of such mechanisms in long-term contracts. It suggests that contractual practices that do not support the *continuous* equitable distribution of the reward for improved energy performance among the client and producer offer limited incentive for the producer to *continually* improve the facility's energy performance through innovation. In fact, Case Study 4 findings, in which the rewards for exceeding the challenging 27kg $CO_2/m^2/yr$ operational carbon target are shared among the ProjectCo and the Local Authority, may indicate that in order to encourage the producer to continuously achieve exceptional results for sustainable energy, incentive-based payments should be linked to the sustainable energy performance of the building.

The above case study findings provide empirical evidence to the limited capacity of the BSF PFI delivery model to support SEI based on key determinants of CoPS innovation. In fact, the research findings identified that only one determinant of CoPS innovation was successful in supporting the SEI outcome, and that is *risk allocation*, particularly the allocation of long-term energy performance risks to producers. This will be explained below:

6. ***Risk Allocation***: Proposition 5 examined the relationship between risk allocation in the BSF PFI delivery model and the SEI outcome. Certainly, the allocation of risk among project participants is considered an important determinant of innovation (Blayse and Manley, 2004; OECD, 2005; Leiringer, 2006; Barlow and Köberle-Gaiser, 2008b). The proposition was

supported on the three innovative BSF PFI projects studied (Case Studies 1, 3 and 4). The SEIs implemented were largely developed as strategies to manage long-term energy performance risks allocated to private sector producers and safeguard their long-term commitment to the project. Contradicting Barlow and Köberle-Gaiser's (2008ab) assertion that the desire to transfer as much risk as possible to ProjectCo actors was not conducive to innovation, the allocation of long-term energy performance risks to ProjectCo actors was found to be most conducive to SEI. Those risks are directly linked to the long-term profitability of the ProjectCo and are thus considered significant enough to encourage innovative activities. Not meeting energy consumption and CO_2 targets exposes the ProjectCo to payment deductions as part of performance-monitoring linked to the Payment Mechanism. Therefore, the ProjectCo is incentivised to avoid penalties for non-compliance, and are, thus, likely to ensure that the building meets agreed energy performance standards. The decision to implement SEIs was driven by top management within the ProjectCo, particularly bid directors and managers, as a strategy to protect their investment. Indeed, Proposition 5 findings indicate that fear of financial penalties is the main driver of SEI on BSF PFI projects.

Proposition 5 also underlined the importance of adequate assessment of those allocated risks by producers in supporting SEI. In fact, while Proposition 5 findings supported previous studies in identifying the importance of greater clarity, appropriateness and manageability of risk allocation for innovation (Leiringer, 2006; Barlow and Köberle-Gaiser, 2008b); the research findings underline the importance of a fourth dimension, and that is the sufficient assessment of risk by producers, in supporting SEI effort. Indeed, it was the adequate assessment of the allocated environmental risks that differentiated the innovative projects (Case Studies 1, 3 and 4) from the project where no innovation was implemented (Case Study 2). The limited assessment of the risks associated with the BREEAM 'Excellent' requirement on SVC (Case Study 2) resulted in the requirement being a considerable challenge to the team post-bidding and was only met at a significant cost in terms of time and resources.

However, while the allocation of energy performance risks to the ProjectCo was an effective driver for SEI, excessive perceived innovation-related risks, particularly capital cost risk, restricted further SEI to be implemented. Indeed, as our study suggests, the need for the ProjectCo to reduce costs to match the approved affordability limits established by the

Public Sector Comparator (PSC) may result in low levels of sustainability innovation on BSF PFI projects. In addition, supporting previous studies such as CIC (2000) and Leiringer (2003), the study identified the incremental nature of the SEI implemented. Indeed, reliability of the technology was an important criterion as the nature of risk allocation in the PFI contract forces producers to adopt tried and tested technologies in order to reduce their risk exposure. However, this preference to incremental innovation weakens the capacity of PFI contracts to deliver the government's zero-carbon objectives as more radical and system innovations are needed to meet such significant reductions in carbon emissions (Huesemen, 2003; Enkvist *et al.*, 2008).

To conclude, the research findings discussed above provide empirical evidence to the limited capacity of the BSF PFI delivery model to support SEI based on key determinants of CoPS innovation. While *clarity of requirement* and *communication and collaboration* were found to be weakened by several factors, *contractual incentives* were found to support SEI, albeit by fear of financial penalties through risk allocation, rather than pursuit of reward. Therefore, it can be argued that the conceptualisation of SEI on the BSF PFI delivery model to be supported by key determinants of innovation proposed in CoPS Innovation Management Theory has not been realised. In fact, the study identified a number of problematic issues, or 'hotspots' (Hansen and Rush, 1998; Hobday and Rush, 1999; Hobday and Brady, 2000), weakening the key determinants of CoPS innovation success in BSF PFI projects. Figure 11.1 (Page 305) displays the main problematic issues identified.

So how can the SEI outcome on the innovative BSF PFI projects studied be explained? While the conceptualisation of SEI to be supported by key determinants of CoPS innovation has been proven to be weak, the research findings suggest that the BSF PFI delivery model may support SEI through more linear Schumpeterian models of innovation, particularly the market-pull model. The market-pull argument is based on the belief that technological change often originates from corporate investment in response to economic incentives (OECD, 2008). Market-pull factors driving environmental innovation are said to include issues such as competitiveness (Sarkis, 1995; Henriques and Sadorsky, 1996) and customer demand for green products (Elkington, 1994; Drumwright, 1994; Howes *et al.*, 1997). On the innovative BSF PFI projects studied, Proposition 1 findings indicate that SEIs were largely developed as competitive strategies to differentiate private sector producers' bids and a marketing strategy to strengthen their environmental credentials. Propositions 2 and 5 findings also identify that the integrated service companies on the innovative projects were encouraged to implement SEIs as corporate strategies to manage the allocated long-term energy performance risks under the DBFO contract and safeguard their long-term commitment to the project. The decision to implement SEIs was driven by top management within the ProjectCo, particularly bid directors and managers, rather than it being the outcome of open communication and effective collaboration among design, construction and operation disciplines. In addition, while collaborative drivers, particularly effective dialogue among ProjectCo actors and Local Authorities, did take place on the innovative projects and was instrumental in clarifying the sustainability requirement, it was achieved despite the *restrictive* BSF process rather than being *supported* by the process. Therefore, it can be proposed that the BSF PFI delivery model is designed to support innovation through more arms-length linear Schumpeterian drivers, particularly the market-pull model, by encouraging competitiveness and profitability considerations through risk allocation rather than the system-oriented model of CoPS. Future quantitative research can further explore this theoretical proposition.

This identified limited capacity of the BSF PFI delivery model to support key determinants of CoPS innovation is, however, detrimental to SEI on BSF projects. The nature of sustainability innovation demands increasing levels of functional dependency and components complexity. Thus, project models that do not support system-oriented drivers of innovation is damaging to SEI development (Rohracher, 2001; Intrachooto and Horayangkura; 2007). Indeed, producers were faced with several problematic issues in their pursuit of SEI on BSF PFI projects, as shown in Figure 11.1 (Page 305). In addition, while innovation did take place on the innovative projects (Case Studies 1, 3 and 4) the main SEIs implemented can be considered as novel combinations of well-known technologies or adaptations of existing systems to new contexts. Indeed, the nature of BSF PFI contractual relationships forces producers to adopt tried and tested technologies in order to minimise their risk exposure and protect their profitability. This bias towards incremental innovation is, however, damaging to SEI as it moves environmental innovation efforts further away from more radical and systemic innovations with the greatest impact and potential to realise zero-carbon objectives (Huesemen, 2003; Enkvist *et al.*, 2008). Therefore, it is fair to argue that the limited capacity of the BSF PFI delivery model to support more system-oriented drivers of innovation, particularly those advanced in CoPS Innovation Management Theory, may represent a considerable challenge to delivering the government's zero-carbon objectives through PFI contracts.

Figure 11.1: BSF PFI Project Delivery Model and SEI: Main Problematic Issues

Clarity of the Requirement

<u>Clarity of Requirement</u>

Clarity of requirement is **weakened** by limited 'specificity' which leaves sustainability open to interpretation and somewhat compromised (Case Studies 1 and 3).

Clarity of requirement is **weakened** by limited 'achievability' which increases the pressure on producers and restricts the innovative interpretation of the requirement (Case Studies 1 and 2).

Communication and Collaboration

<u>Multidisciplinary Communication and Collaboration</u>

Open Design-Operation communication is **weakened** by the use of separated D&B and operational contracts which increases the distance between designers and operators and separate incentives to implement energy-efficient technologies from opportunities to do so (Case Studies 1-4).

Effective Design-Construction collaboration is **weakened** by misalignment of objectives between architects and contractors. The Contractor-led D&B contract restricts the innovative capacity of architects as it leaves architects in a position where key sustainability decisions are controlled by contractors (Case Studies 1-4).

Effective Construction-Operation collaboration is **weakened** by the separation of companies responsible for construction and those responsible for operation. As the Building Contractor carries no operational risk, they are not incentivised to improve the energy performance of the building beyond the minimum requirements (Case Study 2).

<u>Client-Producer Communication and Collaboration</u>

Open Client-Producer communication is **weakened** by highly formalised engagement procedures, which complicates communication processes and fall short of recognising the long-term benefits of the additional upfront cost/ design time needed to establish a clear sustainable energy requirement specific to the client (Case Studies 1-4).

Effective Client-Producer collaboration is **weakened** by clients' limited understanding of their sustainable energy requirement and budgetary constraints (Case Studies 1, 2 and 3).

Effective Client-Producer collaboration is **weakened** by misalignment of objectives stemming from the Local Authority's desire to achieve exceptional results for sustainability and the limited BSF budget available to the Building Contractor (Case Studies 1, 2 and 3).

Effective Client-Producer collaboration is **weakened** by the Contractor-led D&B contract, which restricts the opportunity to build close working relationships among architects and local authorities and weakens the ability of the design to develop and mature (Case Studies 1, 2 and 4).

Effective Client-Producer collaboration is **weakened** by procurement procedures that involve significant design work simultaneously with competitive bidding (Case Studies 1– 4).

<u>User-Producer Communication and Collaboration</u>

Open User-Producer communication is **weakened** by highly formalised engagement processes, which lack adequate appreciation of the long-term benefits of engaging with users in expressing their sustainability aspirations, building their awareness, and developing their capabilities (Case Studies 1–4).

Effective User-Producer collaboration is **weakened** by contract practices that remove the responsibility of the facility's energy performance from users, thus offering limited incentive for users to consider the operational energy performance of the building as their main concern (Case Studies 1–4).

Contractual Incentives

<u>Risk Allocation</u>

Contractual incentives are **weakened** by limited assessment of risk by producers (Case Study 2).

Contractual incentives are **weakened** by excessive perceived innovation-related risks (Case Studies 1–4).

<u>Reward Sharing Mechanisms</u>

Contractual incentives are **weakened** by payment mechanisms that do not support the continuous equitable distribution of the reward for improved energy performance among clients and producers (Case Studies 1, 2 and 3).

Source: Developed for this research study

11.4 Recommendations

This section attempts to answer the study's second research question - ***How can SEI be supported within the BSF PFI project delivery model? -*** by developing a number of recommendations based on theory as well as a priori reasoning that may remedy the identified problematic issues confronted by firms pursuing SEI on BSF PFI projects. While the BSF programme was halted in July 2010, the development of recommendations was necessary in order to capture the lessons learned for the benefit of future projects. Given the centrality of PFI for future government procurement as well as the government's binding commitments under the Kyoto Protocol and its ambitions for zero-carbon schools by 2016, the development of recommendations on how the BSF PFI process should be improved is vital. However, it should be noted that the recommendations made in this section relate specifically to BSF PFI School projects. The recommendations are made based on research findings, which are due to the nature of the chosen research methodology, hypotheses at their current state. The research findings need to be confirmed or rejected by means of quantitative research as representative of all BSF PFI projects. Therefore, caution needs to be taken in implementing the recommendations. Based on the identified problematic issues confronted by firms pursuing SEI on BSF PFI projects (Figure 11.1, Page 305), the research study proposes six potential areas for improvements to enhance the capacity of the BSF PFI delivery model to support SEI as follows:

1. **The Output Specification:** The research study identifies two key areas for improvements related to the BSF PFI Output Specification. Above all, the case study findings identified the need for Local Authorities to ensure greater clarity of the sustainable energy requirement, particularly its 'specificity' and 'achievability'. Limited specificity and achievability of the client's requirement may echo concerns raised by Edler *et al.* (2005) who argue that without adequate preparation of the client requirement and involving key stakeholders, it is likely that adequate understanding of what is needed, and what the suppliers are capable of delivering, will be weak. Successful identification of requirements requires appropriate investment of time and the reconciliation of the expectations, needs, and constraints of a large and diverse set of stakeholders (Edler *et al.*, 2005). Clement *et al.* (2009) also highlight that having technical and market knowledge in the client's team will help the team formulate realistic targets and requirements. Technical expertise is crucial to precisely define needs, assess new technologies, and interact with the market (Clement *et al.*, 2009). Hill and Collins (2004) also argue that clients' teams' capabilities should be checked to meet the programme-level sustainability targets and standards. Therefore, in order to provide

ProjectCo actors with a clear sustainable energy requirement, Local Authorities should ensure that sufficient sustainability advice is available to Core Teams, and that key sustainability and energy expertise are actively involved in sustainability requirement identification. In addition, Local Authority planners can play a key role in sustainability requirement identification and management. Indeed, Jepson (2004) and Briassoulis (1999) research indicates that planners can play a leadership role in the achievement of sustainable development. Planners can improve the specificity of the requirement by undertaking preliminary studies and identifying opportunities for SEIs within the different school sites. Innovative proposals such as energy supply networks linking schools with nearby developments cannot be implemented without the active leadership of planners. Therefore, in order to provide a clear sustainable energy requirement, Local Authorities should actively involve their Planning Departments in writing the sustainable energy requirement and promote the role of planners as leaders for sustainable energy across a wider range of issues than just those directly related to land-use planning and regulation.

In addition, the research study identified three key areas of improvements to the governing framework guiding the development of proposals in BSF projects. First, the study follows calls in the industry and the government, such as the House of Commons (2007), which indicate the need for a much stronger response than BREEAM, because no matter how high a project scored, that would not necessarily indicate low carbon emissions or carbon-neutrality. Moreover, the study identified that existing design guidance may inhibit innovation. Therefore, the relevant public bodies should review the guidance documents and standards governing design development of school buildings to allow for SEI to take place. Furthermore, the low weighting of sustainability and energy issues within BSF bid evaluation criteria needs to be addressed to encourage ProjectCo actors to pursue SEI. Tawiah (2005) argues that properly formulated bid evaluation criteria can act as an effective driver for innovation as they signal to the private sector the reward structure linked with pursuing innovation. Giving sufficient weighting to factors such as energy efficiency and CO_2 emissions when evaluating different bids may work as an effective mechanism to encourage ProjectCo actors to go as far as possible. Therefore, Local Authorities should raise the profile of sustainability and energy issues in their bid evaluation criteria to provide enough incentive for ProjectCo actors to develop SEI. The forthcoming Carbon Reduction

Commitment (CRC)[12] in 2012 as well as the government's target of zero-carbon schools by 2016 may motivate Local Authorities to place a higher weighting for sustainable energy in bid evaluation.

2. **ProjectCo Integration:** The multiple case study findings indicate that the concept of ProjectCo integration deserves further attention, particularly in aligning actors' objectives and priorities to ensure that effective integration between design, construction, and operation is successfully achieved. Therefore, to encourage SEI Local Authorities should formulate bid evaluation criteria that support real integration of the project participants. The ProjectCo, for its part, should also ensure that actors with an incentive to develop SEI are provided with the opportunity to do so. For example, adequate resources should be allocated for facility managers' operational knowledge to be utilised in early design development processes. This will not only stimulate innovation (Leiringer, 2003) but will ensure that schools designed to be energy-efficient will remain so during operation.

3. **Local Authority-ProjectCo Engagement Processes:** The study identifies three key issues that should be taken into consideration for effective BSF Local Authority-ProjectCo engagement processes towards SEI. First, the nature of the BSF engagement process warrants further attention. Indeed, there have been calls for the competitive bidding process to be simplified. The Royal Institute of British Architects (RIBA) has continually highlighted the difficult design process under competitive bidding and called for the process to be replaced by a new model termed 'Smart PFI' or 'The Client Concept Design Model' (RIBA, 2006). The intention is to deliver PFI projects faster and more cheaply. Under the new proposals, building contractors would initially tender for projects by simply costing a 'previously built design' that will be used as a model. In parallel to that, Local Authorities and schools would work closely with an appointed design team to develop detailed design, which will be handed over to the selected Preferred Bidder, or less radically, to two shortlisted bidders. The model is said to reduce procurement time to as little as 44 weeks, compared to the 75 weeks under the BSF model. Cost savings were expected to be approximately 25% of the cost of signing a school deal (RIBA, 2006). In addition, the study highlighted the important role played by Core Teams in supporting effective engagement. Therefore, to support SEI, the Local Authority

[12] The CRC is a mandatory energy efficiency scheme administered by the Environment Agency aimed at improving energy efficiency and cutting emissions in large public and private sector organisations. Local authorities are among the organisations qualifying to enter the scheme and will have to comply legally with the scheme or face financial and other penalties. The scheme provides a financial incentive to reduce energy use by putting a price on carbon emissions and also provides the opportunity for participants to make savings on energy charge through improved energy efficiency. The scheme is predicted to start in 2012 (source: http://www.decc.gov.uk).

should recruit individuals with the necessary technical and leadership skills when staffing the Core Team. With the necessary skills and expertise, these individuals will be able to span the boundary between the Local Authority and the ProjectCo and actively promote the adoption process to the Local Authority. Moreover, the study also demonstrates the need for Local Authorities and ProjectCo actors to create a mutual understanding of each other's needs and objectives. The lack of appreciation of affordability among Local Authorities' actors was considered a major barrier for effective collaboration. Therefore, as Heavisides and Price (2001) advise, cost/quality assessments should be adequately conducted by Local Authority actors prior to tender.

4. **School-ProjectCo Engagement Processes:** The limited involvement of schools in developing SEI during BSF School-ProjectCo engagement processes is a weakness in BSF that needs to be addressed. While schools' priority is understandably education, their role, as the users of the innovative sustainable building, is vital to the development of successful innovation. Users have an important role as it is their requirements and feedback, as to what works and what could be better, that triggers innovation. Active involvement will not only ensure the efficient use of the technology by users in later stages, but it will also identify schools' 'readiness for change' (Clement *et al.*, 2009). Therefore, Local Authorities should ensure that engagement processes are designed to allow sufficient dialogue between schools and bidders. Sustainability and energy issues should also assume a higher profile in schools' requirement identification and discussion with bidders. The forthcoming Carbon Reduction Commitment (CRC) in 2012 should provide an opportunity to incentivise schools though Local Authority engagement.

5. **BSF PFI Risk Allocation:** The research study highlights the importance of appropriate risk allocation on BSF PFI projects. The case study findings identified that the allocation of long-term energy performance risks to ProjectCo actors was successful in providing the ProjectCo with the incentive to improve the energy performance of the project. However, risk management should not stop at this point. Demaid and Quintas (2006) highlight the need for formal procedures for risk management to be built into the management processes for major projects to allow sustainability issues to be integrated into core procedures, rather than being considered as additional, secondary constraints. Indeed, efforts to address the conflicting requirements placed on the ProjectCo and to reduce the perceived limitations of

other risks, such as capital cost risk, may work to induce further innovation for sustainable energy. The following recommendations are thus forwarded:

a. The study identified that perceived capital cost risk was a major inhibitor for SEI. This may indicate the need for the sustainable energy requirement to be clearly reflected in the Public Sector Comparator (PSC). Indeed, the study's findings may indicate that many of the conflicts of interest among the different parties on BSF PFI project arrangement would be reconciled if there was more specific funding channelled toward integrating SEIs. Lockie (2003) argues that the method by which the PSC is calculated is crucial if sustainable buildings are to be delivered through PFI. For example, if the PSC has considered the fact that the scheme must produce 15% of its own energy on site from renewable sources; the ProjectCo would have the incentive to include it in their proposals (Lockie, 2003). Akintoye *et al.* (2003) equally emphasise that 'best value' in the VfM assessment should take into account wider policy objectives. It can thus be argued that delivering the Local Authority's sustainable energy objectives can form an important assessment of 'best value' in the PSC's VfM assessment. Therefore, a vital aspect to obtain more sustainability in PFI would be to build more sustainable features into the PSC model. Indeed, the case study findings may indicate that failing to build sustainable energy into the PSC will result in SEI being abandoned as being 'unaffordable'. Another strategy that may reduce the cost of innovative technologies can be for Local Authorities to come together and form joint procurement (JP), sometimes called bundling of demand (Clement *et al.*, 2009). Local Authorities joining forces to procure innovate energy-efficient technologies (for example PVs), may potentially result in benefits such as reduced risk to individual Local Authorities, lower prices resulting from economies of scale, and bringing in additional expertise and knowledge-sharing (Clement *et al.*, 2009).

b. The limitations to energy supply networks as a result of excessive perceived risk related to their development should be addressed. More can be achieved by exploring opportunities for innovative solutions such as district heating networks, single central CHP system, off-site generation, or utilising a variety of PVs that could be shared across the schools' portfolio. More flexibility in the BSF PFI contract may also allow the introduction of Energy Service Companies (ESCOs) which will fund part of the capital costs and most of the running costs of the renewable energy systems, and thus improve the affordability of the scheme. Therefore, the structure of the BSF PFI contract should be re-assessed to allow the flexibility needed to explore innovative portfolio-based solutions.

c. The study identified that the temperature tolerances forming part of the Availability Clause under the BSF PFI contract may require further attention from policymakers due to its direct conflict with the energy efficiency objective. Indeed, some industry figures such as Bartlett (2008) call for the Availability Clause under PFI to be relaxed if policymakers are serious about zero-carbon schools.

6. **The BSF PFI Payment Mechanism**: The case study findings identified that incentives in the BSF PFI Payment Mechanism are not working effectively to encourage continuous improvement in energy efficiency or the installation of low-carbon technologies mid-contract. Better incentivisation arrangements will need to be developed to ensure schools are maintained and operated to minimise emissions. Some industry figures such as Bartlett (2008) suggest that effective incentive could be to make funding available for retrospect renewable technologies, as advancements within this field make such technologies more feasible and cost-effective to use. In addition, ProjectCo actors should be allowed to claim grants, and validity of these grants should be extended to enable their inclusion within contractual negotiations (Bartlett, 2008). The financial incentives introduced in BWS (Case Study 4) could be replicated to wider BSF schemes. It may also be worth considering the Payment Mechanism developed by the Department of Health for health buildings, which includes incentives for continuous reduction in energy consumption (Sustainable Development Commission, 2006). Therefore, the structure of the BSF PFI Payment Mechanism should be re-assessed to provide the ProjectCo with adequate incentive to strive for continuous improvements for energy efficiency and sustainable energy.

11.5 Limitations of the Study

The first limitation that needs to be highlighted is the contextual nature of the study. The focus of the study is exclusively on BSF PFI projects and this inevitably presents limitations to generalisation. Although this type of study is valuable in meeting the important need to factor the role of context in any conclusions (Leiringer, 2003) and develop concrete, practical, context-dependent knowledge (Flyvbjerg, 2006), the findings and conclusions can only be generalisable to similar BSF PFI projects. The research methodology and philosophical position taken on this research study can also be open to criticism. Data collected in qualitative research tends to be complex and difficult to rigorously analyse, resulting in the objectivity of such data and analysis being questioned (Rintala, 2004). The case study strategy can also be criticised for being inherently non-representative and biased. To counter against these criticisms, special attention has been taken to ensure that the study is theoretically grounded and that it follows a structured research design. In addition, issues of research validity and reliability have been adequately considered, as was discussed in Chapter 5. Moreover, the multi-stakeholder perspective adopted on this research study takes a heavy toll on data collection and analysis. While it ensured triangulation of evidence and allowed the integration of not only ProjectCo actors' perspectives, but also those of Local Authorities and schools, the demand on research resources makes this study very costly to repeat. Finally, it should be noted that the research study focuses on the process of implementing SEI on BSF PFI projects. This report did not attempt to make technical recommendations on how to design innovative energy-efficient school buildings. It did not intend to make the reader an expert in designing energy-efficient school buildings, but rather make him/her capable of better understanding the BSF PFI delivery model and its implications on achieving innovation for sustainable energy in school buildings.

11.6 Contribution to Knowledge

There is a limited number of research studies into the innovative capacity of PPP/PFI project delivery models, particularly within the field of construction management research (Leiringer, 2003, 2006; Eaton *et al.*, 2006; Barlow and Köberle-Gaiser, 2008ab). In addition, there has been no attempt to explore the relationship between PFI and sustainability innovation, including SEI. Therefore, the descriptive case studies, and their subsequent analysis and findings are significant contribution to knowledge. They should prove valuable to both public and private sector actors interested in the delivery of sustainable buildings, not only within BSF but for the PFI sector at large. In addition, the study attends to a significant gap in CoPS research as there is a lack of studies on managing CoPS sustainable innovation processes (Ren and Yeo, 2005), as well as limited attention to procurement issues in the CoPS literature (Cladwell *et al.*, 2009). Indeed, examining the PFI project delivery model through the lens of CoPS indicates that the CoPS model should be expanded to account for the dynamics of sustainable innovation processes in the procurement of sustainable CoPS. Specifically, the study made the following contributions to existing knowledge:

1. Strengthening the theoretical understanding of SEI within PFI project delivery models by analysing sustainable innovation processes using CoPS Innovation Management Theory.

2. Developing a novel conceptual framework to examine the capacity of the PFI project delivery model to support the implementation of SEI. While many studies concerning CoPS innovation have focused on a particular aspect of the process, the framework adopts a holistic approach and explores many aspects of the sustainable design development process. In addition, the perspectives of multiple project participants have been sought; therefore enabling a more thorough and multidisciplinary account of the phenomenon.

3. Providing empirical evidence of the extent to which the BSF PFI project delivery model supports the implementation of SEI based on innovation determinants postulated in CoPS Innovation Management Theory.

4. Identifying the main problematic issues weakening the key determinants of CoPS innovation success in BSF PFI project delivery model.

5. Proposing potential solutions to the problematic issues identified in the implementation of SEI in BSF PFI projects.

Most importantly, this research study provided empirical evidence of the limited capacity of the BSF PFI project delivery model to support SEI based on key determinants advanced in CoPS Innovation Management Theory. The research established that the capacity of the BSF PFI project delivery model to support SEI is weakened by: the limited clarity of the sustainable energy requirement particularly in relation to its ‘specificity’ and ‘achievability’; ineffective multidisciplinary communication and collaboration within the integrated ProjectCo due to restricting internal contractual relationships and misalignment of Design-Construction-Operation sustainability objectives; and ineffective Client/User-Producer communication and collaboration brought in by the restricted nature of BSF engagement processes as well as misalignment of Client/User-Producer sustainability objectives. Contractual incentives were found to support SEI, albeit by fear of financial penalties through risk allocation, rather than pursuit of reward for the innovation. Public and private sector actors interested in the delivery of SEI should address these problematic issues with immediate effect for the benefit of future PFI projects.

11.7 Directions for Future Research

This section identifies three future research agenda that may further develop the issues identified on this research study:

1. An important issue in the achievement of sustainable energy that was beyond the scope of this research is whether a sustainable school building produces the desired effect, i.e. sustainable behaviour in end-use. Future research could build on this study's findings and further explore the case study projects in their operational stages. An interesting research question would be whether the espoused sustainable energy design objectives correlated with experienced sustainable energy performance in operation. Future research could also focus on how the Output Specification, Payment Mechanism and Performance-Monitoring Mechanisms work together during the operational stages of those projects to ensure that the schools remain energy-efficient during operation.

2. Proposition 2 findings indicate that integrated service companies are more incentivised to consider the long-term performance of the building as opposed to separated service companies. The study particularly identified that the integration of companies responsible for construction and those responsible for operation is more conducive to SEI. While the size of the study limited the ability to arrive at a conclusive finding, it was hypothesised that an integrated service company is more encouraged to implement SEI than a separated service company. Building on the work of Brady *et al.* (2005) and Davies *et al.* (2009) on Integrated Solutions Business Models, an important research study would be to clarify and further explore this relationship.

3. The concept of 'Readiness to Deliver Sustainability' was among the key characteristics of innovative Local Authorities identified in our study (Proposition 3 findings). Local Authority actors' competence, understanding of their sustainability requirements, and determination to pursue a specific sustainable energy objective, was particularly important for joint collaboration towards SEI. The concept of 'Readiness to Deliver Sustainability' is closely

related to CoPS Capability Building research (Brady and Davies, 2000, 2004; Yeo and Ren, 2009) and may warrant further attention from policymakers and researchers.

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Appendices

Appendix A: Government Policy and Regulation and how it relates to Sustainability

Table A1: Government Policy Imperatives and how they relate to Sustainability

Policy imperative	What is it about?	What does it mean for sustainability?
Healthy Schools	The National Healthy Schools Programme was established in 1999 with four key themes: personal, social and health education; healthy eating; physical activity; and emotional health and well-being. These relate to both the school curriculum and the emotional and physical learning environment in school. Under each theme there are several criteria that schools need to fulfil in order to achieve national Healthy School status.	The key issues are that improving the health of pupils helps to tackle social aspects of sustainability. The programme also has implications for new schools – especially for the space allowed for dining and physical activity. This may affect management of the grounds, biodiversity and/or energy use.
Every Child Matters (DfES, 2003c)	A new Government approach for all children to get the support they need to be healthy, safe and happy; to succeed in learning and to make a contribution to society; and to achieve economic well-being.	All groups providing services for children will need to work together. The goals are specifically aligned to the social and economic aspects of sustainability: health, social cohesion and a strong economy. There are implications for building design due to the need for co-location of services.
Five-year Strategy for Children and Learners (DfES, 2004a)	A strategy for education through to 2009. It seeks to break the link between lower social class and under-achievement.	The drive for personalised learning, joined-up education and new services from schools will put more pressure on schools and their buildings. More space will be needed, and longer opening hours. This strategy focuses on the social aspects of sustainability.
14–19 Education and Skills (DfES, 2005a)	A White Paper that sets out aims to transform secondary and post-secondary education so that all young people achieve and continue in learning until at least the age of 18.	There are implications for energy use in having larger buildings and more equipment, particularly ICT, being used by more people at any one time.
Extended Schools (DfES, 2005b)	By 2010 all schools will be required to offer a core set of extended services: childcare, parenting support and specialist services such as speech therapy or mental health services.	Longer opening hours are likely to increase resource use. Buildings will need extended heating and lighting into the evening, and schools may also need more space to accommodate the new services, which needs to address social dimensions of sustainability.
Securing the Future (HM Government,2005)	The UK Government's strategy for achieving sustainable development, published in 2005.	Defines the overarching goal of sustainability as enabling 'all people throughout the world to satisfy their basic needs and enjoy a better quality of life, without compromising the quality of life of future generations'. For schools, this means thinking about the global effects of their activities.
Sustainable Schools for Pupils, Communities and the Environment (DfES, 2006)	The Sustainable Schools National Framework, published in 2006.	Describes a sustainable school as one that is committed to care: 'care for oneself, care for each other (across cultures, distances and time), care for the environment (near and far)'. It defines eight 'doorways' for engaging with sustainability.
The Children's Plan (DCSF, 2007a)	The UK Government's 10-year strategy to 'make England the best place in the world for children and young people to grow up'. It sets out a series of ambitions for all areas of children's lives.	It sets out an unequivocal commitment to 'world-class buildings' and that all new schools will be zero carbon by 2016. £110 million will be allocated for sustainable buildings. New buildings will have space for co-located services and parents will have more involvement in school. Investing in safe areas to play at school will be a priority.

Source: Wilkinson (2008)

Table A2: Government Regulations and how they relate to Sustainability

Regulation	What is it about?	What does it mean for sustainability?
BREEAM schools	The Building Research Establishment's Environmental Assessment Method for school buildings. A point-based system that allows schools to see how well designs for new or refurbished buildings are addressing sustainability.	Every newly built and refurbished school must achieve at least a 'Very good' rating, which means scoring points on management, health and well-being, energy use, transport, water, materials, land use and ecology, and pollution.
Part L of the Building Regulations on Energy Conservation	Mandatory minimum standards for new buildings and large refurbishment projects. These mean that all big building projects have to estimate CO_2 emissions from heating and power.	Every new building or large refurbishment for a school must be around 23 per cent more efficient than equivalent buildings built before 2006. This is to reflect some of the requirements of the Energy Performance of Buildings Directive from the European Commission (Janauary, 2006).
Building Bulletin 87 (BB87): Guidelines for Environmental Design in Schools	A technical manual published by the Department for Education and Skills (DfES). Covers energy use, ventilation, lighting and water services in schools.	Sets a standard for energy use in schools, which for secondary schools is 5kgC per m^2 per year.
Building Bulletin 90 (BB90): lighting Design of Schools	A technical manual published by the DfES. It guides architects and engineers through the process of lighting design in the context of the recommended construction standards for schools and the various types of spaces and activities found in schools.	The guide identifies the determining factors of good lighting design as architectural integration, task and activity lighting, visual amenity, cost, maintenance and energy efficiency. It describes the calculation methods and design tools that can be used at the early stages of a project and shows through theory and examples how to achieve synthesis between daylight and electric lighting. Tables of lamps and luminaires give an appreciation of the types of lighting available, their energy efficiency, colour rendering and other characteristics.
Building Bulletin 93 (BB93): Acoustic Design of Schools	A technical manual published by the DfES. Outlines standards for noise entering the school, and for how easy it is to hear someone talking in a class.	The acoustic criteria can preclude natural ventilation for urban schools due to noise caused by open windows. It is recognised that the standards are set high. As a result it is accepted that some schools will not meet them all.
Building Bulletin 98 (BB98): Briefing Framework for Secondary School Projects (Revision of BB82)	Recommended area guidelines for new school buildings. Intended for use in briefing school design teams and explaining how much space will be needed for basic teaching, halls, learning resources, staff and administration, storage, dining and social space.	The new space standards, published in 2004, increase the minimum floor areas for primary schools by 17 per cent and for secondary schools by seven per cent Increased space is being allocated for teaching areas. These stipulations will mean more materials and land are used in construction, and may lead to higher energy consumption.

Source: Wilkinson (2008)

Appendix B: Introductory Interview Participants

List of Introductory Interview Participants:

1. Damian Allen, Director of Children Services, Knowsley Metropolitan Borough Council
2. Alistair Child, BSF Project Manager, Knowsley Metropolitan Borough Council
3. Steve Eastland, Architectural consultant, Devon County Council
4. Dan Lash, Researcher, The Centre for Energy and the Environment, Exeter
5. Malcolm Hopkins, Client Design Advisor, Devon County Council
6. Adrian Gale, CABE Enabler, CABE
7. Andy Seaman, Sustainability Engineer, NPS
8. Richard Butters, Quantity Surveyor, Morgan Ashurst
9. George Martin, Head of Sustainability, Wilmot Dixon
10. Magali Thomson, Project Architect, Marks Barfield
11. Alex Lawrence, Project Engineer, Gifford Structures
12. Marcel Hendricks, Project Manager, Apollo Education
13. Ian Jamieson, Partner, Sprunt
14. Susan Anderton, Development Manager, Sprunt
15. David Graham, Project Architect, Pollard Thomas & Edwards Ltd

Appendix C: List of Case Study Participants

Table C1: List of Case Study Participants

No.	Case Study Project	Organization Name	Organization Role	Participant Role	Interview Location	Gender	Date of interview	Form of Interview
A1	Brislington Enterprise College- Bristol	Bristol City Council	Local Authority	BSF Project Director	Bristol	M	04/04/09	Meeting
A2	Brislington Enterprise College- Bristol	Bristol LEP	LEP	Bid Manager	Bristol	M	16/07/09	Meeting
A3	Brislington Enterprise College- Bristol	Sustainable City Team	Local Authority	Sustainability Coordinator	Bristol	F	16/07/09	Meeting
A4	Brislington Enterprise College- Bristol	Atkins	Technical Consultant	Technical/Design Advisor	Bristol	M	23/07/09	Meeting
A5	Brislington Enterprise College- Bristol	Bristol City Council	Local Authority	Energy Management Officer	Bristol	M	02/09/09	Meeting
A6	Brislington Enterprise College- Bristol	FLACQ	Architect	Project Director	-	M	03/09/09	Phone interview
A7	Brislington Enterprise College- Bristol	Wilkinson Eyre	Architect	Project Director	London	M	09/09/09	Meeting
A8	Brislington Enterprise College- Bristol	Skanska Construction	Main Contractor	Design Manager	Bristol	M	28/09/09	Meeting
A9	Brislington Enterprise College- Bristol	Bristol City Council	Local Authority	Planning officer	Bristol	M	08/10/09	Meeting
A10	Brislington Enterprise College- Bristol	Skanska FM	Facility Manager	General Manager	Bristol	M	02/02/10	Meeting
A11	Brislington Enterprise College- Bristol	Buro Happold	M&E Consultant	Project Leader	Bath	M	11/02/10	Meeting
A12	Brislington Enterprise College- Bristol	Buro Happold	M&E Consultant	Project Engineer	Bath	F	11/02/10	Meeting
A13	Brislington Enterprise College- Bristol	Brislington Enterprise College	End user	Principal	Bristol	M	04/05/10	Meeting
B1	Soar Valley College- Leicester	LMEC	LEP	BSF Bid Manager	Leicester	M	13/08/09	Meeting
B2	Soar Valley College- Leicester	Leicester City Council	Local Authority	BSF Project manager	Leicester	M	04/09/09	Meeting
B3	Soar Valley College- Leicester	G4S	Facility Manager	FM Design Coordinator	Leicester	M	03/11/09	Meeting
B4	Soar Valley College- Leicester	ADP	Architect	Project Director	London	M	18/12/09	Meeting
B5	Soar Valley College- Leicester	ADP	Architect	Project Director	Birmingham	F	15/02/10	Meeting
B6	Soar Valley College- Leicester	Miller Construction	Contractor	Operations Manager	Ashby	M	24/02/10	Meeting
B7	Soar Valley College- Leicester	Gifford	M&E	Project Engineer	Manchester	M	02/03/10	Meeting
B8	Soar Valley College- Leicester	Leicester City Council	Local Authority	In house Technical/ Design Advisor	Leicester	M	24/03/10	Meeting
B9	Soar Valley College- Leicester	Leicester City Council	Local Authority	Sustainability and Low Carbon Building Officer	Leicester	F	09/04/10	Meeting
B10	Soar Valley College- Leicester	Leicester City Council	Local Authority	Sustainability Manager	Leicester	M	13/04/10	Meeting
B11	Soar Valley College- Leicester	Leicester City Council	Local Authority	Senior Planning Officer	Leicester	F	13/04/10	Meeting
B12	Soar Valley College- Leicester	Soar Valley College	End user	Business Manager	-	M	28/04/10	Phone interview
B13	Soar Valley College- Leicester	Leicester City Council	Local Authority	Senior Officer- Environment Team	-	F	30/04/10	Phone interview

Cont. Table C1: List of Case Study Participants

Nos.	Case Study Project	Organization Name	Organization Role	Participant Role	Interview Location	Gender	Date of interview	Form of Interview
C1	Highbury Grove School- London	Islington Council	Local Authority	Head of Sustainability	London	F	16/04/09	Meeting
C2	Highbury Grove School- London	BDP	Architect	Project Director	London	M	29/04/09	Meeting
C3	Highbury Grove School- London	Islington Council	Local Authority	BSF Project Manager	London	M	14/05/09	Meeting
C4	Highbury Grove School- London	Islington Council	Local Authority	Senior Planning Officer	London	F	09/06/09	Meeting
C5	Highbury Grove School- London	Islington Council	Local Authority	Energy Manager	London	F	30/09/09	Meeting
C6	Highbury Grove School- London	Atkins	Technical Advisor	Technical Advisor	Bristol	M	28/09/09	Meeting
C7	Highbury Grove School- London	Balfour Beatty Capital	Equity Provider	Whole Life Cost Director	Newcastle	M	18/03/10	Meeting
C8	Highbury Grove School- London	Balfour Beatty Work Place	Facility Management	Operations Manager	London	M	30/03/10	Meeting
C9	Highbury Grove School- London	Balfour Beatty Capital	Equity Provider	Assistant Bid Manager	London	M	07/05/10	Meeting
C10	Highbury Grove School- London	Balfour Beatty Construction	Building Contractor	Operations Manager	London	M	07/05/10	Meeting
C11	Highbury Grove School- London	BDP	M&E Engineer	Project Engineer	London	M	12/05/10	Meeting
C12	Highbury Grove School- London	Highbury Grove School	End user	Head Teacher	London	F	14/05/10	Meeting
D1	Big Wood School- Nottingham	Gedling Borough Council	Local Authority	Principal Planning Officer	-	F	06/10/09	Phone Interview
D2	Big Wood School- Nottingham	Inspired Spaces	LEP	Bid Director	London	M	09/10/09	Meeting
D3	Big Wood School- Nottingham	Capita Architecture	Architect	Project Architect	Cardiff	M	20/10/09	Meeting
D4	Big Wood School- Nottingham	Capita	M&E Engineer	Project Engineer	Cardiff	M	20/10/09	Meeting
D5	Big Wood School- Nottingham	Nottingham City Council	Local Authority	Design Manager	Nottingham	M	03/11/09	Meeting
D6	Big Wood School- Nottingham	Big Wood School	End User	Head Teacher	Nottingham	F	08/12/09	Meeting
D7	Big Wood School- Nottingham	Carillion Construction	D&B Contractor	Operations Manager	Nottingham	M	12/12/09	Meeting
D8	Big Wood School- Nottingham	Faithful & Gould	Technical Advisor	Technical Advisor	Nottingham	M	08/12/09	Meeting
D9	Big Wood School- Nottingham	Faithful & Gould	Technical Advisor	Sustainability Advisor	Nottingham	F	01/02/10	Meeting
D10	Big Wood School- Nottingham	Carillion FM	Facility Manager	Contract Manager	Nottingham	M	23/02/10	Meeting
D11	Big Wood School- Nottingham	LowC	Carbon Consultant	Project Manager	Stamford	M	24/02/10	Meeting
D12	Big Wood School- Nottingham	Carillion Construction	D&B Contractor	Education Director	London	M	15/04/10	Meeting

Appendix D: Case Study Interview Protocol

The Bartlett School of Graduate Studies

Case Study Interview Protocol

Preliminary Information

Name: -- Title: --
Organization: -- Role: ---
Address: -- Tel: --------------------------

1. Introduction

Thank you very much for agreeing to participate in this research study. Your response to this interview will support a PhD study, conducted at the Bartlett School of Graduate Studies, University College London, on the capacity of the PFI project delivery model to support the implementation of SEI on BSF new-build school projects. The fundamental research questions underpinning this research study are:

Q1: What is the capacity of the PFI project delivery model to support the implementation of SEI on BSF new-build school projects?

Q2: How can SEI be encouraged within BSF PFI project delivery model?

2. The Interview

The interview will take approximately 1 hour of your time. We are interested in your experience on the project and your interaction with other organizations during the key design development stages of the project. We are also interested in your opinion on the conditions that led to the implementation of the SEI. The Interview Protocol consists of seven sections as follows:

Section 1: Your role on the project
Section 2: Your organization's role on the project
Section 3: The SEIs implemented on the project
Section 4: Clarity of the requirement
Section 5: Communication and collaboration
Section 6: Risk allocation
Section 7: Reward sharing mechanisms

3. Confidentiality

Please be assured that all information will be held in the strictest confidence. Only non-attributed data will be used in any subsequent publication.

4. Interview Administration

- Would you mind if I record the interview as it will help with the data analysis? We can stop the recording at any point throughout the interview.
- Are there any further questions either about the interview procedure or the purpose of the research?
- If you wish I would be very happy to provide you with a summary of the results.

SECTION 1: Your Role on the Project

1.1. To the best of your knowledge, when did you start working on this project?

1.2. Which role best describes your responsibilities on this project?

1.3. Time with your organization: -------

1.4. Time in the industry: -------

1.5. What position do you hold within your team?

1.6. What level are you within your organization?

1.7. What is your professional and educational background?

SECTION 2: Your Organization's Role on the Project

2.1. Who appointed your organization?

2.2. Who paid for the services provided by your organization?

2.3. At what stage did your organization join the project?

2.4. Which role best describes your organization's responsibilities?

2.5. What do you perceive to be the key elements of the services that your organization provided on this project?

1. ---
2. ---

SECTION 3: The SEI Implemented on the Project

Note: *Sustainable Energy Innovations (SEIs) are defined on this research study as those novel technological products or solutions that are successfully integrated into design strategies in order to prevent or substantially reduce the negative impacts of energy use by increasing energy efficiency, or utilising new ways of renewable energy generation.*

3.1. We have identified XXXX as being one such successfully implemented SEI on this project. Do you agree with our view on this? why? why not?

3.2. Were there any other SEI implemented on the project?

3.3. At the time of conceptualisation, how novel was this idea in your opinion? to your organisation, to the UK's construction industry, to the construction industry world-wide, to other industries?

3.4. Compared to current practice at the time, what was the degree of change that the innovation brought with it?

3.5. What were the believed benefits of this particular innovation? Why was it believed to be better than other solutions?

3.6. Why had this particular innovation not been applied to a similar project before?.

SECTION 4: Clarity of the Requirement

To Local Authority/School interviewees:

4.1. Can you describe the Local Authority overall policy/strategy regarding sustainability and energy efficiency?

4.2. Can you describe the Local Authority objectives in terms of sustainability on its BSF programme?

4.3. Was your team involved in the drafting of the Output Specification? What role did your team play?

4.4. How often did your team communication with the following teams during the writing of the requirement:

- The Core Team
- Sustainability Unit
- Energy Management Unit
- Planners
- School

4.5. Were there any other parts of the local authority with significant involvement?

4.6. How did the Output Specification documents set out programme-wide energy efficiency requirements?

4.7. How did the Output Specification document set out project specific energy efficiency requirements?

4.8. Were there any difficulties in the drafting of the requirement?

To ProjectCo interviewees:

4.9. How would you describe the Sustainable energy requirements in the Output Specification? Were they principally:

a. Generalised statements about policy and regulations
b. Technical type (defining the technical and physical characteristics of its items (e.g. CHP or Biomass boilers)
c. Performance type (defining the environmental performance required)
d. Mandatory outcome-based type (defining for example carbon emission targets)

4.10. Can you describe the degree of clarity of the sustainable energy requirement and governing framework in the Output Specification? To what extent the sustainable energy requirement and governing framework were free from confusion, uncertainty, ambiguity, or doubt?

4.11. Were there any aspects of the Output Specification and governing framework with which your organisation was not completely satisfied? How did this affect the sustainable and energy efficient outcome of the project?

4.12. Do you have further comments on the standard BSF PFI Output Specification ?

SECTION 5: Communication and Collaboration

Note: *In this section we will explore collaborative relationships towards SEI. This research study defines* ***openness of communication*** *as the extent to which your organisation/team has communicated* ***directly*** *with the other organisations/teams concerned during the design development process.* ***Effectiveness of collaboration*** *is defined as the extent to which your organisation/team has worked with the other organisations/teams concerned* ***Jointly towards a common SEI goal****.*

Taking the above definitions of open communication and joint collaboration into consideration:

5.1. Relationship with ProjectCo actors:

5.1.1. How direct was the communication between your organisation and the teams below during the design development process?

a. The Bid Management Team
b. The Architect
c. M&E Engineer
d. The Building Contractor
e. The Facility Manager

5.1.2. How collaborative was the relationship between your organisation and the teams above towards towards a common SEI goal?

5.1.3. What kind of problems or difficulties did you have in relating to the above teams? How did this affect the sustainable and energy efficient outcome of the project?

5.2. Relationship with the Local Authority:

5.2.1. How direct was the communication between your organisation and the following teams within the Local Authority during BSF engagement processes?

a. The Core Team
b. Sustainability Unit
c. Energy Management Unit
d. Planners

5.2.2. How collaborative was the relationship between your organisation and the Local Authority's Sustainability expertise towards a common SEI goal?

5.2.3. What kind of problems or difficulties did you have in relating to the Authority's sustainability expertise? How did this affect the sustainable and energy efficient outcome of the project?

5.3. Relationship with the School:

5.3.1. How direct was the communication between your organisation and the School during BSF engagement processes?

5.3.2. How collaborative was the relationship between your organisation and the School towards a common SEI goal?

5.3.3. What kind of problems or difficulties did you have in relating to the School? How did this affect the sustainable and energy efficient outcome of the project?

SECTION 6: Risk Allocation

Note: *In this section we will explore the risks associated with the energy strategy. This research study defines* ***clear*** *risk allocation as that free from confusion, uncertainty, ambiguity, or doubt.* ***Appropriate*** *risk allocation is defined as that fitting for a particular entity or situation.* ***Manageable*** *risk allocation is defined as that that can be managed or controlled.*

Taking the above definitions of clear, appropriate and manageable risk allocation into consideration:

6.1. How clear was the allocation of the risks associated with the energy strategy on this project?

6.2. In your opinion, was the allocation of the risks associated with the energy strategy appropriate? What, if any, risks were non-negotiable?

6.3. Were there any specific risks associated with the energy strategy that should have been allocated differently? Do you think that the affected actors were/are clear over the risks that they were taking on?

6.4. In your opinion was the risk allocated to your organisation manageable?

6.5. What were the most probable risks to materialise for your organisation? How did the innovation influence these probabilities?

6.6. What were the most probable risks to materialise for the project as a whole? How did the innovation influence these probabilities?

6.7. What were the most significant risks for your organisation should they materialise? When were you clear that you had to take those risks? How did the innovation impact (positive or negative) on the way you handled these risks?

SECTION 7: Reward Sharing Mechanisms

7.1. Do you understand how the standard BSF PFI Energy Payment Mechanism operates?

7.2. How does the standard BSF PFI Energy Payment Mechanism impact on your organisation's incentive to provide a high level of sustainability and energy efficiency?

7.3. Do you have further comments on the standard BSF PFI Energy Payment Mechanism?

Closing comments

• Are there any other points you would like to make on areas that we have not mentioned that would help me understand your opinion with regard to the implementation of SEI within the context of this project?

Your contribution to this research is greatly appreciated, Thank you!

Appendix E: Summary of Case Study Findings

Table E1: BEC (Case Study 1): Summary of Key Findings

Proposition	Key Constructs	Emergent Issues	Case study Findings	Case Study Interviewees												
				L 1	L 2	L 3	L 4	L 5	P 1	P 2	P 3	P 4	P 5	P 6	P 7	S 1
(Box E1.1) Proposition 1	(Box E1.1.1) Clarity of the Sustainable Energy Requirement	Specificity of the Sustainable Energy Requirement	Requirement lacked specificity (-)						•		•	•	•	•		
			Output-based specification left sustainability open to interpretation and somewhat compromised (-)						•		•	•				
			Difficulty of translating higher level sustainability objectives into physical solutions to be implemented (-)						•		•	•				
			Local Authority actors seen as 'broad concept people' and unable to articulate requirement (-)						•		•	•				
			Output-nature of requirement increased fear of suggesting high-cost innovative technologies (-)						•		•	•				
	(Box E1.1.2) Clarity of the Governing Framework	BREEAM	Offered limited incentives for SEI (-)								•	•	•			
		Weighting on Bid Evaluation	Low weighting discouraged SEI (-)						•		•	•	•			
			Sustainability seen as a strategy to win the contract (+)						•		•	•				
(Box E1.2) Proposition 2	(Box E1.2.1) Openness of Communication	Design-Construction Communication	Contractor appointed Architect at bid stage, thus, constructability information reached the Design Team early during the design development process (+)									•	•			
		Design-Facility Management Communication	Facility Manager appointed by ProjectCo, thus, one step removed from designers (-)									•	•	•		
			Limited involvement of Facility Manager during bid stage due to limited resources (-)						•	•				•		
	(Box E1.2.2) Effectiveness of Collaboration	Alignment of Objectives between Architect-Contractor	Relationships collaborative and trustful (+)						•	•	•	•	•			
			'Awkward' position of Design Team because their ability to pursue SEI depended on Local Authority and Contractors preference (-)								•	•	•			
			Conflict of objectives between Architect's desire to produce a 'statement' building and limited budget available to Building Contractor (-)								•	•	•			
			Contractor's interest in meeting minimum requirement (-)								•	•	•			
		Alignment of Objectives between Contractor-Facility Manager	Ability of company to deliver design, build, and operation was incentive to achieve best energy solution (+)						•	•					•	
(Box E1.3) Proposition 3	(Box E1.3.1) Openness of Communication	Nature of BSF Engagement Process	Engagement process 'difficult, 'restricted', 'time-consuming', 'exhausting' and tightly managed (-)				•		•	•	•	•	•			
			Large number of stakeholders complicated engagement (-)				•				•	•				
			Sustainability not high on the discussion agenda (-)				•		•	•	•	•				
			confidentiality issues complicated communication (-)	•	•		•		•	•	•	•				
		Local Authority-ProjectCo Interface Management	Clear information flow enabled by single points of contact (+)	•	•		•		•	•	•	•				
			Active involvement of Sustainable City Team enabled clear commitment to sustainability (+)				•		•	•	•	•				
			Lack of understanding within Core Team of amount of consultation needed (-)		•		•	•	•	•	•	•				
			Lack of involvement of Energy Management Unit (-)					•								
	(Box E1.3.2) Effectiveness of Collaboration	Local Authority 'Readiness to Deliver Sustainability'	Local Authority actors seen as 'broad concept people' (-)						•	•	•	•				
		Alignment of Objectives between Local Authority and ProjectCo	Lack of adequate appreciation of affordability within Local Authority (-)						•	•	•	•				
			Misalignment of objectives between Local Authority and profit-seeking Contractors (-)	•	•		•	•								
			No collaboration between Contractor and Energy Management Unit (-)					•								
		Architect-Local Authority Relationship	Architect-Local Authority relationship was restricted during engagement (-)	•	•						•	•				
		Nature of BSF Engagement Process	Local Authority actors 'levelled out' bids, resulting in bids becoming similar and restricted innovation (-)						•		•					
			Local Authority 'played one bid against the other'. ProjectCo constantly in 'playing field' whilst bidding (-)						•		•					
			Synthesis needed between aesthetical quality and sustainability (-)								•	•				

Note: (•) indicate that the issue originated from the perception of the case study interviewee, (+) indicate that the issue has a positive effect on construct, (-) indicate that the issue has negative effect on construct.
Source: Developed for this research study.

Cont. Table E1: BEC (Case Study 1): Summary of Key Findings

Proposition	Key Constructs	Emergent Issues	Case study Findings	Case Study Interviewees												
				L 1	L 2	L 3	L 4	L 5	P 1	P 2	P 3	P 4	P 5	P 6	P 7	S 1
Box E1.4) Proposition 4	(Box E1.4.1) Openness of Communication	Nature of BSF Engagement Process	Organised engagement meetings allowed engagement (+)						•		•	•				
			Committed Head Teacher supported engagement (+)						•		•	•	•			
			Communication controlled by Core Team (-)						•		•	•	•			•
			Design team working under Building Contractor, thus, one step removed from School (-)								•	•	•			
			Limited time allocated was restricting (-)						•		•	•				•
			Formal and competitive nature of engagement restricting (-)						•		•	•				
			Confidentiality issues restricting (-)						•		•	•				
			School transferred ideas between bids increased pressure on ProjectCo (-)						•							
			Open communication after appointment of Preferred Bidder (+)								•	•				•
	(Box E1.4.2) Effectiveness of Collaboration	Alignment of Objectives between School and ProjectCo	School interested in educational benefits of sustainable design (+)						•		•	•				•
			Sustainability low on School's agenda (-)						•		•	•				•
			School's lack of technical knowledge about sustainability (-)						•		•	•				•
			Conflict between transformational learning aspiration and energy conscious design (-)						•		•	•				•
			Conflict between School's educational requirement and sustainability requirement due to limited BSF budget (-)						•		•	•				•
			PFI contract reduces School's control over building (-)						•		•	•				•
(Box E1.5) Proposition 5	(Box E1.5.1) Clarity of Risk Allocation	Clarity of Energy-related Risks	Risk allocation was clear on BSF documentation (+)						•	•	•	•	•	•	•	
	(Box E1.5.2) Appropriateness of Risk Allocation	Appropriateness of Energy-related Risks	Risk allocation fair and acceptable (+)						•	•	•	•	•	•	•	
			Conflicting requirements and excessive perceived availability risk damaging to energy efficiency (-)						•	•	•	•	•	•		
	(Box E1.5.3) Manageability of Risk Allocation	The Management of Energy-related Risks as a Driver for SEI	Availability risk was main driver for innovative chimney design (+)						•	•	•	•	•	•		
		Strategies to Manage Innovation-related Risks	Perceived technical risk managed by undertaking numerous prototyping and simulation tests								•	•	•	•		
			Chimney design not to be 'too experimental' to safeguard investment and long-term commitment to project								•	•	•	•		
			Chimney design predominantly new combination of tried and tested technologies								•	•	•	•		
		Unmanageability of Innovation-related Risks as Barrier to Innovation	Perceived technical risks led to adoption of tried and tested technologies (-)													
			Perceived capital cost risk inhibited adoption of high-cost technologies with long payback periods (-)													
(Box E1.6) Proposition 6	(Box E1.6.1) Reward Sharing Mechanisms	Incentives in Payment Mechanism linked to Improved Energy Performance	Limited incentive in Payment Mechanism to improve energy performance mid-contract (-)						•	•	•	•	•	•	•	

Note: (•) indicate that the issue originated from the perception of the case study interviewee, (+) indicate that the issue has a positive effect on construct, (-) indicate that the issue has negative effect on construct.
Source: Developed for this research study.

Table E2: SVC (Case Study 2): Summary of Key Findings

Proposition	Key Constructs	Emergent Issues	Case study Findings	Case Study Interviewees												
				L 1	L 2	L 3	L 4	L 5	L 6	P 1	P 2	P 3	P 4	P 5	P 6	S 1
(Box E2.1) Proposition 1	(Box E2.1.1) Clarity of the Sustainable Energy Requirement	Specificity of the Sustainable Energy Requirement	Output-based specification provided flexibility to innovate (+)							•		•	•	•		
		Achievability of the Sustainable Energy Requirement	zero carbon requirement seen as unrealistic both technically and financially (-)							•	•	•	•	•		
	(Box E2.1.2) Clarity of the Governing Framework	BREEAM	BREEAM main driver for sustainability on project (+)							•	•	•	•	•		
			Offered limited incentives for SEI (-)							•	•	•	•	•		
		Weighting on Bid Evaluation	Low weighting discouraged SEI (-)							•	•	•	•	•		
(Box E2.2) Proposition 2	(Box E2.2.1) Openness of Communication	Design-Construction Communication	Early discussions on constructability, affordability and project planning supported by Contractor appointing Architect at bid stage (+)									•	•	•		
		Design team-Facility Management Communication	Facility Manager appointed by ProjectCo, thus, one step removed from designers (-)									•	•	•	•	
			Limited involvement of Facility Manager during bid stage due to limited resources (-)												•	
			Lack of joint problem solving between design team and Facility Manager (-)									•	•	•	•	
	(Box E2.2.2) Effectiveness of Collaboration	Alignment of Objectives between Architect-Contractor	A 'team approach' adopted and relationships open and honest (+)								•	•	•			
			BSF process allocated considerable power to Building Contractor and put Architect in a position where key decisions were controlled by Contractor (-)									•	•	•		
			Contractor's interest seen to win bid and then meet minimum sustainability requirement with least investment (-)									•	•	•		
		Alignment of Objectives between Contractor-Facility Manager	Building Contractor responsibility ends when building is handed over. Facility Manager assume responsibility of building for next 25 years (-)								•					
(Box E2.3) Proposition 3	(Box E2.3.1) Openness of Communication	Nature of BSF Engagement Process	Large forums with many stakeholders involved (-)	•						•	•	•	•	•		
			Communication was difficulty because it has to be equal and uniform across all bidders (-)	•						•	•	•	•	•		
			Limited time allocated to design process reflected in low quality of bids received (-)							•	•	•	•	•		
		Local Authority-ProjectCo Interface Management	Clear information flow enabled by single points of contact (+)	•						•	•	•	•	•		
			Engagement process tightly managed by Local Authority Core Team (-)		•	•	•	•	•	•	•	•	•	•		
			Lack of recognition within Core Team of intensity and volume of work needed to manage engagement (-)		•	•	•	•	•	•	•	•	•	•		
			Lack of involvement of in-house sustainability expertise (-)		•	•	•	•	•	•	•	•	•	•		
			Depth and quality of information received by ProjectCo unsatisfactory (-)							•	•	•	•	•		
			Local Authority seen not to understand sustainability and CO_2 reduction requirement (-)							•	•	•	•	•		
			Lack of dialogue to clarify Local Authority commitment to sustainability (-)		•	•	•	•	•	•	•	•	•	•		
	(Box E2.3.2) Effectiveness of Collaboration	Local Authority 'Readiness to Deliver Sustainability'	Local Authority actors lacked adequate understanding of their requirement (-)							•	•	•	•	•		
		Alignment of Objectives between Local Authority and ProjectCo	Lack of appreciation of affordability within Local Authority (-)							•	•					
			Local Authority actors with no power or influence, with project dominated by Contractor (-)	•				•								
			Contractor seen to do minimum to achieve required BREEAM outcome (-)	•	•	•	•	•	•			•	•	•		
			Contractor inflexible to Authority's requirements and pushing through with decisions (-)	•	•	•	•	•	•							
		Architect-Local Authority Relationship	Architect-Local Authority relationship was restricted during engagement (-)									•	•	•		
		Nature of BSF Engagement Process	Synthesis needed between aesthetical quality and sustainability (-)									•	•	•		

Note: (•) indicate that the issue originated from the perception of the case study interviewee, (+) indicate that the issue has a positive effect on construct, (-) indicate that the issue has negative effect on construct.
Source: Developed for this research study.

Cont. Table E2: SVC (Case Study 2): Summary of Key Findings

Proposition	Key Constructs	Emergent Issues	Case study Findings	Case Study Interviewees												
				L 1	L 2	L 3	L 4	L 5	L 6	P 1	P 2	P 3	P 4	P 5	P 6	S 1
(Box E2.4) Proposition 4	(Box E2.4.1) Open**ness of** Communication	Nature of BSF Engagement Process	Organised engagement meetings allowed engagement (+)							•	•	•	•	•		•
			Committed School Engagement Team supported communication (+)							•		•	•	•		
			Controlled by Core Team (-)							•		•	•	•		
			Design team working under Building Contractor, thus, one step removed from School (-)							•		•	•	•		
			Engagement Process 'difficult' and 'restricted' (-)							•		•	•	•		
			Engagement process formal, time consuming and exhausting (-)													•
			Separate meetings between school and ProjectCo partners complicated communication (-)													•
			Change of ProjectCo personnel post bidding frustrating to School (-)													•
			Open communication after appointment of Preferred Bidder (+)							•		•	•	•		•
	(Box E2.4.2) Effectiveness of Collaboration	Alignment of Objectives between School and ProjectCo	School interested in educational benefits of sustainable design (+)							•		•	•	•		•
			Sustainability low on School's agenda (-)							•	•	•	•	•		
			School's lack of technical knowledge about sustainability (-)									•	•	•		•
			Conflict between transformational learning aspiration and energy conscious design (-)							•		•	•	•		
			Conflict between School's educational requirement and sustainability requirement due to limited BSF budget (-)							•	•	•	•	•		
(Box E2.5) Proposition 5	(Box E2.5.1) Clarity of Risk Allocation	Limited assessment of Energy-related Risks	Building Contractor's limited understanding and assessment of BREEAM risk complicated design process (-)									•	•	•		
	(Box E2.5.2) Appropriateness of Risk Allocation	Appropriateness of Energy-related Risks	Risk allocation fair and acceptable (+)							•	•	•	•	•	•	
	(Box E2.5.3) Manageability of Risk Allocation	Unmanageability of Innovation-related Risks as Barrier to Innovation	Perceived technical risks led to adoption of safe and robust technology (a biomass boiler) (-)							•	•	•	•	•		
			Perceived capital cost risk inhibited adoption of high-cost technologies (-)							•	•	•	•	•		
			Perceived planning approval risk restricted adoption of a wind turbine (-)									•	•	•		
(Box E2.6) Proposition 6	(Box E2.6.1) Reward Sharing Mechanisms	Incentives in Payment Mechanism linked to Improved Energy Performance	Limited incentive in Payment Mechanism to improve energy performance mid-contract (-)	•	•					•	•	•	•	•	•	

Note: (•) indicate that the issue originated from the perception of the case study interviewee, (+) indicate that the issue has a positive effect on construct, (-) indicate that the issue has negative effect on construct.
Source: Developed for this research study

Table E3: HGS (Case Study 3): Summary of Key Findings

Proposition	Key Constructs	Emergent Issues	Case study Findings	Case Study Interviewees											
				L 1	L 2	L 3	L 4	L 5	P 1	P 2	P 3	P 4	P 5	P 6	S 1
(Box E3.1) Proposition 1	(Box E3.1.1) Clarity of the Sustainable Energy Requirement	Specificity of the Sustainable Energy Requirement	Output-based specification provided flexibility to innovate (+)						•	•	•	•	•	•	
			Challenging targets seen as main driver of energy efficiency (+)						•	•	•	•	•	•	
			Requirement seen as generic and did not reflect specificity of school sites (-)							•	•	•	•		
			Clarity of requirement restricted by large amount of information included (-)							•	•	•	•		
		Achievability of the Sustainable Energy Requirement	Change of requirement midway through process was challenging (-)							•	•				
	(Box E3.1.2) Clarity of the Governing Framework	BREEAM	Offered limited incentives for SEI (-)						•	•	•	•	•	•	
		Design Standards	BB83 restricted innovation (-)									•	•		
(Box E3.2) Proposition 2	(Box E3.2.1) Openness of Communication	Design-construction Communication	Contractor appointed Architect at bid stage, thus, they worked closely (+)							•	•	•	•		
		Design team-Facility Management Communication	Facility Manager appointed by ProjectCo, thus, one step removed from designers (-)							•	•	•	•	•	
			Limited involvement of facility managers in design development decisions (-)									•	•	•	
	(Box E3.2.2) Effectiveness of Collaboration	Alignment of Objectives between Architect-Contractor	Challenging relationship between Architect and Building Contractor (-)								•	•	•		
			Contractor saw sustainability as a 'burden' and were not in a 'state of readiness' to deliver it (-)									•	•		
			Architect found it difficult to ensure the Building Contractor's commitment to Architect's 'Design Intent' (-)									•			
			Architect had no access to cost information and poor exposure to supply chain (-)									•			
		Alignment of Objectives between Contractor-Facility Manager	ability of company to deliver design, build, and operation was incentive to achieve best energy solution (+)						•	•	•	•	•	•	
(Box E3.3) Proposition 3	(Box E3.3.1) Openness of Communication	Nature of BSF Engagement Process	Engagement process 'massively bureaucratic', 'cumbersome', 'time-consuming' and 'frustrating' (-)		•		•		•	•	•	•	•		
			Mammoth amount of meetings the Local Authority needed to attend with all bidders was exhausting (-)	•	•	•	•	•							
			BSF process prescriptive and pushes sustainability and energy issues down priority list (-)	•	•	•	•	•	•	•	•	•	•		
		Local Authority-ProjectCo Interface Management	Clear information flow enabled by single points of contact (+)	•	•	•	•	•	•	•	•	•	•		
			Local Authority requirement made clear to bidders through structured engagement (+)						•	•	•	•	•		
			Sustainability Unit, Energy Management Unit and Planning Department actively involved, providing clarity to the Local Authority's sustainability objectives and aspiration (+)	•	•	•	•	•	•	•	•	•	•		
			Sustainability Unit championing sustainability across the Local Authority (+)	•	•	•	•	•				•	•		
	(Box E3.3.2) Effectiveness of Collaboration	Local Authority 'Readiness to Deliver Sustainability'	Sustainability Unit was important source of sustainability knowledge to Architect (+)		•							•	•		
			Local Authority and Sustainability Unit in a 'state of readiness' to push forward a very sustainable agenda (+)						•	•	•	•	•		
		Alignment of Objectives between Local Authority and ProjectCo	Tensions in relation to what Local Authority wanted to achieve for sustainability, and budget allocated (-)	•	•	•	•	•	•	•	•	•	•		
			Engagement post bidding seen to complicate design process and lead to unrealistic sustainability demands (-)						•	•	•				
		Architect-Local Authority Relationship	Architect-Local Authority relationship was largely collaborative (+)	•	•	•	•	•	•	•	•	•	•		
		Nature of BSF Engagement Process	Local Authority played one bid against the other' which made it difficult for ProjectCo to win bid (-)						•		•				
			Fear of giving away good ideas whilst bidding (-)						•		•	•	•		
			Reluctance of bidders to put time and resources into design whilst bidding due to risks involved (-)	•		•	•	•	•		•				
			Detail design post Preferred Bidder may compromise sustainability (-)	•	•	•	•	•				•	•		

Note: (•) indicate that the issue originated from the perception of the case study interviewee, (+) indicate that the issue has a positive effect on construct, (-) indicate that the issue has negative effect on construct.
Source: Developed for this research study.

Cont. Table E3: HGS (Case Study 3): Summary of Key Findings

Proposition	Key Constructs	Emergent Issues	Case study Findings	Case Study Interviewees											
				L 1	L 2	L 3	L 4	L 5	P 1	P 2	P 3	P 4	P 5	P 6	S 1
(Box E3.4) Proposition 4	(Box E3.4.1) Openness of Communication	Nature of BSF Engagement Process	Organised engagement meetings allowed engagement (+)						•	•	•	•	•		•
			Engagement process largely restricted (-)						•		•	•	•		•
			Discussions on sustainability restricted by Education Advisor (-)									•	•		
			Design team working under Building Contractor, thus, one step removed from School (-)									•	•		
			Engagement process time consuming and exhausting to School (-)												•
	(Box E3.4.2) Effectiveness of Collaboration	Alignment of Objectives between School and ProjectCo	School interested in educational benefits of sustainable design (+)						•	•	•	•	•		•
			Sustainability low on School's agenda (-)	•	•				•	•	•	•	•		•
			School's lack of technical knowledge about sustainability (-)									•	•		•
			Conflict between School's educational requirement and sustainability requirement due to limited BSF budget (-)						•		•	•	•		•
			Conflict between School's educational requirement and sustainability requirement due to limited BSF budget (-)						•		•	•	•		
(Box E3.5) Proposition 5	(Box E3.5.1) Clarity of Risk Allocation	Clarity of Energy-related Risks	Risk allocation clear on BSF documentation (+)						•	•	•	•	•	•	
	(Box E3.5.2) Appropriateness of Risk Allocation	Appropriateness of Energy-related Risks	Risk allocation fair and acceptable (+)						•		•	•	•	•	
			Allocation of initial carbon target risk to Building Contractor seen to be somewhat unfair (-)							•					
	(Box E3.5.3) Manageability of Risk Allocation	The Management of Energy-related Risks as a Driver for SEI	Energy consumption risk, availability risk and planning approval risk drove innovative design (+)						•	•	•	•	•		
		Strategies to Manage Innovation-related Risks	Energy simulation models were critical to ensure targets are met and minimise risk									•	•		
			Perceived planning approval risk managed by discussions with planners									•	•		
			Innovation is new combination of best available technologies in market						•	•	•	•	•		
		Unmanageability of Innovation-related Risks as Barrier to Innovation	Perceived capital cost risk inhibited adoption of high-cost technologies with long payback periods (-)						•	•	•	•	•		
			Perceived off-take and construction risks restricted energy supply networks (-)			•			•	•	•	•	•		
(Box E3.6) Proposition 6	(Box E3.6.1) Reward Sharing Mechanisms	Incentives in Payment Mechanism linked to Improved Energy Performance	Limited incentive in Payment Mechanism to improve energy performance mid-contract (-)						•	•	•	•	•	•	
			lack of clauses in the Payment Mechanism to commit the ProjectCo into using the renewable technology (-)	•				•							
			Reluctance of PfS to move away from standard documents (-)	•				•	•	•	•	•	•	•	

Note: (•) indicate that the issue originated from the perception of the case study interviewee, (+) indicate that the issue has a positive effect on construct, (-) indicate that the issue has negative effect on construct.
Source: Developed for this research study

Table E4: BWS (Case Study 4): Summary of Key Findings

Proposition	Key Constructs	Emergent Issues	Case study Findings	Case study Interviewees											
				L1	L2	L3	L4	P1	P2	P3	P4	P5	P6	P7	S1
(Box E4.1) Proposition 1	(Box E4.1.1) Clarity of the Sustainable Energy Requirement	Specificity of the Sustainable Energy Requirement	Output-based specification provided flexibility to innovate (+)					•	•	•	•	•	•	•	
			Sustainable energy requirement was made clear in the Output Specification (+)					•	•	•	•	•	•	•	
			Challenging targets seen as main driver of energy efficiency (+)					•	•	•	•	•	•		
			Clear preference to specific technologies reduced fear that suggesting undesirable or high-cost technologies could jeopardise bid (+)					•			•	•	•		
		Achievability of the Sustainable Energy Requirement	Introduction of carbon target, coupled with additional funding, encouraged innovative CHP solution (+)					•	•	•	•				
	(Box E4.1.2) Clarity of the Governing	BREEAM	BRREAM key criteria for energy efficiency (+)					•			•	•	•		
			BRREAM offered limited incentives for SEI (-)					•			•	•	•		
		Weighting on Bid Evaluation	Low weighting of sustainability and energy issues on bid evaluation discouraged SEI (-)					•	•	•	•	•	•		
(Box E4.2) Proposition 2	(Box E4.2.1) Openness of Communication	Design-Construction Communication	Contractor and Architect benefited from discussing constructability issues early at bid stage (+)					•	•	•	•				
		Design team-Facility Management Communication	Facility Manager appointed by ProjectCo, thus, one step removed from designers (-)							•	•	•		•	
			Limited involvement of Facility Manager during bid due to limited resources (-)											•	
			Difficulty of appointing operational Facility Manager without compromising original job (-)											•	
			Lack of joint problem solving between design team and Facility Manager (-)											•	
	(Box E4.2.2) Effectiveness of Collaboration	Alignment of Objectives between Architect-Contractor	Architect working under difficult position as they were pushed by needs of bids and personalities within Local Authority and Contractor (-)								•	•			
			Architect's agenda not necessarily cost (-)								•	•			
			Architect had no access to cost information and poor exposure to supply chain (-)								•	•			
			Architect controlled, restricted, and driven to 'tokenistic' and 'Eco- Bling' strategies (-)								•				
			Design team had fewer quantity of consultants that could be outside BSF (-)								•	•			
			New personnel on Contractor's delivery team fought for tried and tested solutions rather than what promised during bid (-)								•	•			
		Alignment of Objectives between Contractor-Facility Manager	ability of company to deliver design, build, and operation was incentive to achieve best energy solution (+)					•	•	•	•	•	•	•	
			Introduction of operational carbon target and placing obligation on Contractor encouraged team to design and operate building efficiently (+)					•	•	•	•	•	•	•	
(Box E4.3) Proposition 3	(Box E4.3.1) Openness of Communication	Nature of BSF Engagement Process	Multiple elements discussed during engagement meetings and sustainability not high on agenda (-)	•	•	•	•	•			•	•	•		
			Magnitude of stakeholders involved during engagement complicated design process (-)								•	•	•		
		Local Authority-ProjectCo Interface Management	Clear information flow enabled by single points of contact (+)	•	•	•	•	•	•	•	•	•	•		
			Core Team, Design Manager and Sustainability Advisor able to challenge bidders' proposals, allowing Local Authority Commitment to be clear to bidders (+)					•	•	•	•	•	•		
			Design Manger championing sustainability across the Local Authority (+)	•	•	•	•								
	(Box E4.3.2) Effectiveness of Collaboration	Local Authority 'Readiness to Deliver Sustainability'	Local Authority Core Team receptive, supportive, encouraging and willing to accept new ideas (+)					•	•	•	•	•	•		
			Local Authority Core Team clear about their sustainability requirements and determined to pursue a specific sustainable energy objective (+)					•	•	•	•	•	•		
		Alignment of Objectives between Local Authority and ProjectCo	Local Authority and ProjectCo working collaboratively (+)	•	•	•	•	•	•	•	•	•	•	•	
		Architect-Local Authority Relationship	Architect-Local Authority relationship was restricted during engagement (-)								•	•			
		Nature of BSF Engagement	The design needed to move rapidly from Stage D to F. Consequently stage E, was often lost on BSF (-)								•	•			

Note: (•) indicate that the issue originated from the perception of the case study interviewee, (+) indicate that the issue has a positive effect on construct, (-) indicate that the issue has negative effect on construct.
Source: Developed for this research study.

Cont. Table E4: BWS (Case Study 4): Summary of Key Findings

Proposition	Key Constructs	Emergent Issues	Case study Findings	Case study Interviewees											
				L 1	L 2	L 3	L 4	P 1	P 2	P 3	P 4	P 5	P 6	P 7	S 1
(Box E4.4) Proposition 4	(Box E4.4.1) Openness of Communication	Nature of BSF Engagement Process	Organised engagement meetings allowed engagement (+)					•	•	•	•	•			•
			Committed School Engagement Team supported communication (+)					•	•	•	•	•			•
			Controlled by Core Team (-)					•	•	•	•	•			
			Too many actors from the Local Authority's side complicated communication (-)					•	•	•	•	•			
			Design team working under Building Contractor, thus, one step removed from School (-)								•	•			
			Engagement process formal, restricted, time consuming and exhausting (-)					•			•	•			•
			Open communication after appointment of Preferred Bidder (+)					•		•	•	•			•
	(Box E4.4.2) Effectiveness of Collaboration	Alignment of Objectives between School and ProjectCo	School interested in educational benefits of sustainable design (+)					•		•	•	•			•
			Sustainability low on School's agenda (-)					•		•	•	•			•
			School's lack of technical knowledge about sustainability (-)					•		•	•	•			•
			Conflict between transformational learning aspiration and energy conscious design (-)					•		•	•	•			•
			PFI contract reduces School's control over building (-)					•		•	•	•			•
(Box E4.5) Proposition 5	(Box E4.5.1) Clarity of Risk Allocation	Clarity of Energy-related Risks	Risk allocation clear on BSF documentation (+)					•	•	•	•	•	•	•	
	(Box E4.5.2) Appropriateness of Risk Allocation	Appropriateness of Energy-related Risks	Risk allocation fair and acceptable (+)					•		•	•	•	•	•	
			The 27kg $CO_2/m^2/yr$ target seen by Education Director to be onerous and difficult to close out (-)						•						
	(Box E4.5.3) Manageability of Risk Allocation	The Management of Energy-related Risks as a Driver for SEI	Operational carbon target risk main driver for innovative CHP solution (+)					•	•	•	•	•	•	•	
		Strategies to Manage Innovation-related Risks	Technical risk managed by appointing an Energy Consultant					•					•		
			Bid Director was instrumental in overcoming resistance to innovation					•	•				•		
			Innovation not necessarily 'risk-taking' and CHP purchased from well-known manufacturer					•	•	•			•		
			Perceived planning approval risk managed by discussions with planners					•			•	•	•		
		Unmanageability of Innovation-related Risks as Barrier to Innovation	Perceived capital cost risk inhibited adoption of high-cost technologies with long payback periods (-)					•		•	•	•	•		
(Box E4.6) Proposition 6	(Box E4.6.1) Reward Sharing Mechanisms	Incentives in Payment Mechanism linked to Improved Energy Performance	Incentive-payment mechanism linked to 27kg $CO_2/m^2/yr$ carbon target encourages continuous improvements (+)					•	•	•	•	•	•	•	
			Effectiveness of measure depends on how it will be monitored and enforced					•					•		

Note: (•) indicate that the issue originated from the perception of the case study interviewee, (+) indicate that the issue has a positive effect on construct, (-) indicate that the issue has negative effect on construct.
Source: Developed for this research study

Appendix F: Cross-Case Findings

Table F1: BSF PFI Output Specification and Implication for SEI: Summary of Key Findings

Key Constructs	Emergent Issues	Case study 1 Findings	Case study 2 Findings	Case study 3 Findings	Case study 4 Findings
Clarity of the Sustainable Energy Requirement	**(Box F1.1)** **Specificity of the Sustainable Energy Requirement**	Requirement lacked specificity (-) Output-based specification left sustainability open to interpretation and somewhat compromised (-) Difficulty of translating higher level sustainability objectives into physical solutions to be implemented (-) Local Authority actors seen as 'broad concept people' and unable to articulate requirement (-) Output-nature increased fear of suggesting high-cost innovative technologies (-)	Output-based specification provided flexibility to innovate (+)	Output-based specification provided flexibility to innovate (+) Challenging targets seen as main driver for energy efficiency (+) Requirement seen as generic and did not reflect specificity of school sites (-) Clarity of requirement restricted by large amount of information included (-)	Output-based specification provided flexibility to innovate (+) Clear preference to specific technologies reduced fear that suggesting undesirable or high-cost technologies might jeopardise bid (+)
	(Box F1.2) **Achievability of the Sustainable Energy Requirement**	-	zero carbon requirement seen as unrealistic both technically and financially (-)	Change of requirement midway through process was challenging (-)	Introduction of carbon target, coupled with additional funding, encouraged innovative CHP solution (+)
Clarity of the Governing Framework	**(Box F1.3)** **BREEAM**	Offered limited incentives for SEI (-)	Main driver of sustainability on project (+) Offered limited incentives for SEI (-)	Offered limited incentives for SEI (-)	Offered limited incentives for SEI (-)
	(Box F1.4) **Design Standards**	-	-	BB93 restricted innovation (-)	-
	(Box F1.5) **Weighting of Sustainability and Energy Requirement on BSF Bid Evaluation**	Low weighting discouraged SEI (-)	Low weighting discouraged SEI (-)	-	Low weighting discouraged SEI (-)

Note: (+) indicate that the issue has a positive effect on construct, (-) indicate that the issue has negative effect on construct.
Source: Developed for this research study.

Table F2: Communication and Collaboration within the Integrated ProjectCo and Implication for SEI: Summary of Key Findings

Key Constructs	Emergent Issues	Case study 1 Findings	Case study 2 Findings	Case study 3 Findings	Case study 4 Findings
Openness of Communication	**(Box F2.1)** **Design-Construction Communication**	Contractor appointed Architect at bid stage, thus, constructability information reached the Design Team early (+) Relationships collaborative and trustful (+)	Early discussions on constructability, affordability and project planning supported by Contractor appointing Architect at bid stage (+) A 'team approach' adopted and relationships open and honest (+)	Contractor appointed Architect at bid stage, thus, working closely together (+)	Contractor and Architect **benefited from discussing** constructability issues early at bid stage (+)
	(Box F2.2) **Design-Facility Management Communication**	Facility Manager appointed by ProjectCo, thus, one step removed from designers (-) Limited involvement of Facility Manager during bid stage due to limited resources (-)	Facility Manager appointed by ProjectCo, thus, one step removed from designers (-) Limited involvement of Facility Manager during bid stage due to limited resources (-) Lack of joint problem solving between design team and Facility Manager (-)	Facility Manager appointed by ProjectCo, thus, one step removed from designers (-) Commercial Facility Management team involved with design team at bid stage (+)	Facility Manager appointed by ProjectCo, thus, one step removed from designers (-) Limited involvement of Facility Manager during bid due to limited resources (-) Difficulty of appointing operational Facility Manager without compromising original job (-) Lack of joint problem solving between design team and Facility Manager (-)
Effectiveness of collaboration	**(Box F2.3)** **Alignment of Objectives between Architect-Contractor**	'Awkward' position of design team because their ability to pursue SEI depended on Local Authority and Contractors preference (-) Conflict of objectives between Architect's desire to produce a 'statement' building and limited budget available to Building Contractor (-) Contractor's interest in meeting minimum requirement (-)	BSF process allocated considerable power to Building Contractor and put Architect in a position where key decisions were controlled by Contractor (-) Architect's focus on 'wow' factors and statement buildings and Contractor decided building specification (-) Contractor's interest seen to win bid and then meet minimum sustainability requirement with least investment (-)	Challenging relationship between Architect and Building Contractor (-) Contractor saw sustainability as a 'burden' and were not in a 'state of readiness' to deliver it (-) Architect found it difficult to ensure the Building Contractor's commitment to Architect's 'Design Intent' (-) Architect had no access to cost information and poor exposure to supply chain (-)	Architect working under difficult position as they were pushed by needs of bids and personalities within Local Authority and Contractor (-) Architect's agenda not necessarily cost (-) Architect had no access to cost information and poor exposure to supply chain (-) Architect controlled, restricted, and driven to 'tokenistic' and 'Eco- Bling' strategies (-) Design team had fewer quantity of consultants that could be outside BSF (-) New personnel on Contractor's delivery team fought for tried and tested solutions rather than that promised during bid (-)
	(Box F2.4) **Alignment of Objectives between Contractor-Facility Manager**	ability of company to deliver design, build, and operation was incentive to achieve best energy solution (+)	Building Contractor responsibility ends when building is handed over. Facility Manager assume responsibility of building for next 25 years (-)	ability of company to deliver design, build, and operation was incentive to achieve best energy solution (+)	ability of company to deliver design, build, and operation was incentive to achieve best energy solution (+) Introduction of operational carbon target and placing obligation on Contractor encouraged team to design and operate building efficiently (+)

Note: (+) indicate that the issue has a positive effect on construct, (-) indicate that the issue has negative effect on construct.
Source: Developed for this research study.

Table F3: Local Authority-ProjectCo Communication and Collaboration and Implication for SEI: Summary of Key Findings

Key Constructs	Emergent Issues	Case study 1 Findings	Case study 2 Findings	Case study 3 Findings	Case study 4 Findings
Openness of Communication	**(Box F3.1)** **Nature of BSF Engagement Process**	Engagement process 'difficult, 'restricted' 'time-consuming' 'exhausting' and tightly managed (-) Large number of stakeholders complicated engagement (-) Sustainability not high on the discussion agenda (-) confidentiality issues complicated communication (-)	Large forums with many stakeholders involved (-) Communication was difficulty because it has to be equal and uniform across all bidders (-)	Engagement process 'massively bureaucratic', 'cumbersome', 'time-consuming' and 'frustrating' (-) Mammoth amount of meetings the Local Authority needed to attend with all bidders was exhausting (-) BSF process prescriptive and pushes sustainability and energy issues down priority list (-)	Multiple elements discussed during engagement meetings and sustainability not high on agenda (-) Magnitude of stakeholders involved during engagement complicated design process (-)
	(Box F3.2) **Local Authority-ProjectCo Interface Management**	Clear information flow enabled by single points of contact (+) Active involvement of Sustainable City Team enabled clear commitment to sustainability(+) Lack of understanding within Core Team of amount of consultation needed (-) Lack of involvement of Energy Management Unit (-)	Clear information flow enabled by single points of contact (+) Engagement process tightly managed by Local Authority Core Team (-) Lack of recognition within Core Team of intensity and volume of work needed to manage engagement (-) Lack of involvement of in-house sustainability expertise (-) Depth and quality of information received by ProjectCo unsatisfactory (-) Local Authority seen not to understand sustainability and CO_2 reduction requirement (-) Lack of dialogue to clarify Local Authority commitment to sustainability (-)	Clear information flow enabled by single points of contact (+) Local Authority requirement made clear to bidders through structured engagement (+) Sustainability Unit, Energy Management Unit and Planning Department actively involved, providing clarity to the Local Authority's sustainability objectives and aspiration (+) Sustainability Unit championing sustainability across the Local Authority (+)	Clear information flow enabled by single points of contact (+) Core Team, Design Manager and Sustainability Advisor able to challenge bidders' proposals, allowing Local Authority Commitment be made clear to bidders (+) Design Manger championing sustainability across the Local Authority (+)

Note: (+) indicate that the issue has a positive effect on construct, (-) indicate that the issue has negative effect on construct.
Source: Developed for this research study.

Cont. Table F3: Local Authority-ProjectCo Communication and Collaboration and Implication for SEI: Summary of Key Findings

Key Constructs	Emergent Issues	Case study 1 Findings	Case study 2 Findings	Case study 3 Findings	Case study 4 Findings
Effectiveness of collaboration	**(Box F3.3)** **Local Authority 'Readiness to Deliver Sustainability'**	Local Authority actors seen as 'broad concept people' (-)	Local Authority actors lacked adequate understanding of their requirement (-)	close relationship between Architect and Sustainability Unit (+) Sustainability Unit was important source of sustainability knowledge to Architect (+) Local Authority and Sustainability Unit in a 'state of readiness' to push forward a very sustainable agenda (+)	Local Authority Core Team receptive, supportive, encouraging and willing to accept new ideas (+) Local Authority Core Team clear about their sustainability requirements and determined to pursue a specific sustainable energy objective (+)
	(Box F3.4) **Alignment of Objectives between Local Authority and ProjectCo**	Lack of adequate appreciation of affordability within Local Authority (-) Misalignment of objectives between Local Authority and profit-seeking Contractors (-) No collaboration between Contractor and Energy Management Unit (-)	Lack of appreciation of affordability within Local Authority (-) Local Authority actors with no power or influence, with project dominated by Contractor (-) Contractor seen to do minimum to achieve required BREEAM outcome (-) Contractor inflexible to Authority's requirements and pushing through with decisions (-)	Tensions in relation to what Local Authority wanted to achieve for sustainability, and BSF budget allocated (-) ProjectCo actors felt engagement with Local Authority will complicate design process and lead to unrealistic sustainability demands (-)	Local Authority and ProjectCo working collaboratively (+)
	(Box F3.5) **Architect-Local Authority Relationship**	Architect-Local Authority relationship was restricted during engagement (-)	Architect-Local Authority relationship was restricted during engagement (-)	Architect-Local Authority relationship was largely collaborative (+)	Architect-Local Authority relationship was restricted during engagement (-)
	(Box F3.6) **Nature of BSF Engagement Process**	Local Authority actors 'levelled out' bids, resulting in bids becoming similar and restricted innovation (-) Local Authority 'played one bid against the other'. ProjectCo constantly in 'playing field' whilst bidding (-) Synthesis needed between aesthetical quality and sustainability (-)	Limited time allocated to design process reflected in low quality of bids received (-) Synthesis needed between aesthetical quality and sustainability (-)	Local Authority played one bid against the other' which made it difficult for ProjectCo to win bid (-) Fear of giving away good ideas whilst bidding (-) Reluctance of bidders to put time and resources into design whilst bidding due to risks involved (-) Detail design post Preferred Bidder may compromise sustainability (-)	The design needed to move rapidly from Stage D to F. Consequently stage E, was often lost on BSF (-) Difficulties of ensuring that sustainability promises made during the bid are actually delivered afterwards (-)

Note: (+) indicate that the issue has a positive effect on construct, (-) indicate that the issue has negative effect on construct.
Source: Developed for this research study

Table F4: School-ProjectCo Communication and Collaboration and Implication for SEI: Summary of Key Findings

Key Constructs	Emergent Issues	Case study 1 Findings	Case study 2 Findings	Case study 3 Findings	Case study 4 Findings
Openness of Communication	**(Box F4.1)** **Nature of BSF Engagement Process**	Organised engagement meetings allowed engagement (+) Committed Head Teacher supported engagement(+) Communication controlled by Core Team (-) Design team working under Building Contractor, thus, one step removed from School (-) Limited time allocated restricting (-) Formal and competitive nature of engagement restricting (-) Confidentiality issues restricting (-) School transferred ideas between bids increased pressure on ProjectCo (-) Open communication after appointment of Preferred Bidder (+)	Organised engagement meetings allowed engagement (+) Committed School Engagement Team supported communication(+) Controlled by Core Team (-) Design team working under Building Contractor, thus, one step removed from School (-) Engagement Process 'difficult' and 'restricted' (-) Engagement process formal, time consuming and exhausting (-) Separate meetings between school and ProjectCo partners complicated communication (-) Change of ProjectCo personnel post bidding frustrating to School (-) Open communication after appointment of Preferred Bidder (+)	Organised engagement meetings allowed engagement (+) Engagement process largely restricted (-) Discussions on sustainability restricted by Education Advisor (-) Design team working under Building Contractor, thus, one step removed from School (-) Engagement process time consuming and exhausting to School (-)	Organised engagement meetings allowed engagement (+) Committed School Engagement Team supported communication (+) Controlled by Core Team (-) Design team working under Building Contractor, thus, one step removed from School (-) Limited time allocated restricting (-) Engagement process formal, time consuming and exhausting (-) Too many actors from the Local Authority's side (-) Open communication after appointment of Preferred Bidder (+)
Effectiveness of Collaboration	**(Box F4.2)** **Alignment of Objectives between School and ProjectCo**	School interested in educational benefits of sustainable design (+) Sustainability low on School's agenda (-) School's lack of technical knowledge about sustainability (-) Conflict between transformational learning aspiration and energy conscious design (-) Conflict between School's educational requirement and sustainability requirement due to limited BSF budget (-) PFI contract reduces School's control over building (-)	School interested in educational benefits of sustainable design (+) Sustainability low on School's agenda (-) School's lack of technical knowledge about sustainability (-) Conflict between transformational learning aspiration and energy conscious design (-) Conflict between School's educational requirement and sustainability requirement due to limited BSF budget (-) -	School interested in educational benefits of sustainable design (+) Sustainability low on School's agenda (-) School's lack of technical knowledge about sustainability (-) Conflict between School's educational requirement and sustainability requirement due to limited BSF budget (-) School's requirement contradicted the objective to reduce their overall carbon emission (-)	School interested in educational benefits of sustainable design (+) Sustainability low on School's agenda (-) School's lack of technical knowledge about sustainability (-) Conflict between transformational learning aspiration and energy conscious design (-) PFI contract reduces School's control over building (-)

Note: (+) indicate that the issue has a positive effect on construct, (-) indicate that the issue has negative effect on construct.
Source: Developed for this research study

Table F5: Risk Allocation and Implication for SEI: Summary of Key Findings

Key Constructs	Emergent Issues	Case study 1 Findings	Case study 2 Findings	Case study 3 Findings	Case study 4 Findings
Clarity of Risk Allocation	**(Box F5.1)** **Clarity of Energy-related Risks**	Risk allocation clear on BSF documentation (+)	Building Contractor's limited understanding and assessment of BREEAM risk complicated design process (-)	Risk allocation clear on BSF documentation (+)	Risk allocation clear on BSF documentation (+)
Appropriateness of Risk Allocation	**(Box F5.2)** **Appropriateness of Energy-related Risks**	Risk allocation fair and acceptable (+) Conflicting requirements and excessive perceived availability risk damaging to energy efficiency (-)	Risk allocation fair and acceptable (+)	Risk allocation fair and acceptable (+) Allocation of initial carbon target risk to Building Contractor seen by ProjectCo WLC Director to be somewhat unfair (-)	Risk allocation fair and acceptable (+) The 27kg $CO_2/m^2/yr$ target seen by Education Director to be onerous and difficult to close out (-)
Manageability of Risk Allocation	**(Box F5.3)** **The Management of Energy-related Risks as a Driver for SEI**	Availability risk was main driver for innovative chimney design (+)	-	Energy consumption risk, availability risk and planning approval risk drove innovative design (+)	Operational carbon target risk main driver for innovative CHP solution (+)
	(Box F5.4) **Strategies to Manage Innovation-related Risks**	Perceived technical risk managed by undertaking numerous prototyping and simulation tests Chimney design not to be 'too experimental' to safeguard investment and long-term commitment to project Chimney design predominantly new combination of tried and tested technologies	-	Energy simulation models were critical to ensure targets are met and minimise risk Perceived planning approval risk managed by discussions with planners Innovation is new combination of best available technologies in market	Technical risk managed by appointing an Energy Consultant Bid Director was instrumental in overcoming resistance to innovation Innovation not necessarily 'risk-taking' and CHP purchased from well-known manufacturer Perceived planning approval risk managed by discussions with planners
	(Box F5.5) **Unmanageability of Innovation-related Risks as Barrier to Innovation**	Perceived technical risks led to adoption of a new combination of well-known technologies (-) Perceived capital cost risk inhibited adoption of high-cost technologies with long payback periods (-) Perceived planning approval risk restricted installation of a wind turbine (-)	Perceived technical risks led to adoption of safe and robust technology (a biomass boiler) (-) Perceived capital cost risk inhibited adoption of high-cost technologies (-) Perceived planning approval risk restricted adoption of a wind turbine (-)	Perceived capital cost risk inhibited adoption of high-cost technologies with long payback periods (-) Perceived off-take and construction risks associated with energy supply networks restricted their development (-)	Perceived capital cost risk inhibited adoption of high-cost technologies with long payback periods (-)

Note: (+) indicate that the issue has a positive effect on construct, (-) indicate that the issue has negative effect on construct.
Source: Developed for this research study

Table F6: The Payment Mechanism and Implication for SEI: Summary of Key Findings

Key Constructs	Emergent Issues	Case study 1 Findings	Case study 2 Findings	Case study 3 Findings	Case study 4 Findings
Reward Sharing Mechanisms	**(Box F6.1) Limited incentives in standard Payment Mechanism linked to Improved Energy Performance**	Limited incentive in Payment Mechanism to improve energy performance mid-contract (-)	Limited incentive in Payment Mechanism to improve energy performance mid-contract (-)	Limited incentive in Payment Mechanism to improve energy performance mid-contract (-) lack of clauses in the Payment Mechanism to commit the ProjectCo into using the renewable technology (-) Reluctance of PfS to move away from standard documents (-)	-
	(Box F6.2) Introduction of additional incentives encouraged SEI				Incentive-payment mechanism linked to 27kg $CO_2/m^2/yr$ carbon target encourages continuous improvements (+)

Note: (+) indicate that the issue has a positive effect on construct, (-) indicate that the issue has negative effect on construct.
Source: Developed for this research study