The Code for Sustainable Homes: what are the innovation implications for the social housing development sector?

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Declaration

The author declares that no portion of the work referred to in this thesis has been submitted in support of an application for another degree or qualification of this or any other university or other institute of learning.

Catherine Barlow
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Abbreviations

BERR	Department for Business Enterprise and Regulatory Reform
BRE	Building Research Establishment
CCHA	County Council Highway Authority
Code	Code for Sustainable Homes
CoPS	Complex Product System
DBIS	Department for Business, Information and Skills
DCLG	Department for Communities and Local Government
DER	Dwelling Emission Rate
DIUS	Department for Innovation, Universities and Skills
ESRC	Economic and Social Research Council
HA	Housing Association
HCA	Homes and Communities Agency
HLP	Heat Loss Parameters
LA	Local Authority
NAHP	National Affordable Housing Programme
NAO	National Audit Office
NHBC	National House Building Council
ONS	Office for National Statistics
SCRI	Salford Centre for Research and Innovation, University of Salford
SERC	Science and Engineering Research Council
SI	Systems Integrator
SOEC	Statistical Office of the European Communities
TER	Target Emission Rate

Abstract

The research considers the capacity of the social housing development sector to generate or accelerate innovation to meet the Code for Sustainable Homes, the national standard detailing targets for the sustainability of new housing, within project and organisational resource constraints. Innovation in response to the Code needs to be appropriate within the context of multiple organisations acting together to design and deliver housing developments that are timely and cost-effective.

The literature review synthesises the themes of innovation, regulation and projects in the context of housing development. The review finds that research into the generation of innovation across the range of organisations involved in early housing design projects to meet these multiple regulatory requirements is found to be both recent and limited in quantity.

The research approach for addressing the research questions is justified as a single exploratory case study, and techniques for data collection include semi-structured interviews, workshops and document review. Analysis of data generates a detailed review of the dynamic process of the design of a social housing development by project partners involved in innovative ways of working to meet Code requirements in a landscape of significant and multiple new and established site-specific, local, regional and national regulations.

The research finds that the impact of the Code at the design stage is one of negotiation around existing building techniques and recent technologies to reduce CO_2 emissions within business finance models and physical site limitations affecting orientation and placement of homes. The Code operates within a range of design requirements defined by project partners at this early stage, and innovation to meet these requirements is predominantly incremental, within a process of iteration, negotiation, compromise and solution.

The research outcome makes a contribution to knowledge by extending construction management theory on the relationship between housing construction project innovation and regulation in the context of improving housing sustainability. It achieves this by exploring and illuminating the complex nature of a compelling contemporary, real world situation of a national sector responding to the urgent global imperative to address carbon reduction whilst delivering sustainable social housing.

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Chapter One: Introduction

1.1 Introduction

This Chapter introduces the thesis with a consideration of the policy background as a framework for the research problem, which informs the research aim, objectives and approach. The Chapter concludes with a synopsis of the thesis.

1.2 Background and context of research

The recent environment for the housing development sector is significantly shaped by government policies and, specifically, by three drivers for more, better and cheaper housing, summarised in the policy statement 'Homes for the future: more affordable, more sustainable' (Department for Communities and Local Government, 2007a) which in turn are responses to broader global and national circumstances. These three issues characterise the defining policy framework within which the sector now needs to operate and are summarised below.

The primary housing policy is one of increasing the volume of housing, and associated policies are enacted within this context. Policy states that three million new homes are needed by 2020 (bringing housing stock to approximately 25 million in England). This volume can be achieved by building increasing numbers of homes every year, rising to 240,000 a year by 2016 (DCLG 2007a: 6). Secondly, the average house costs over 8 times the average salary and by 2011, 70,000 new homes a year will be 'affordable', for either rent or purchase (DCLG 2007a: 9)[1]. Thirdly, sustainability of new houses is a key element of the policy commitment to build well-designed housing for mixed communities with good local infrastructures to support them (DCLG 2007a: 8).

[1] There are various definitions of and supporting arguments for affordability, for example 'housing where there is an intervention in the market through public subsidy' (NAO, 2005). The government uses regional measurements of the ratio of lower quartile house prices to earnings (Meen & Andrew, 2007).

These three issues are expressed as parallel policy objectives in government documents and can be summarised as more, more affordable and better housing. All three policy objectives need to be addressed as new (or recent) drivers that will generate, or at least accelerate, a flow of innovation to meet the government's targets of more, more affordable and more sustainable housing.

As a focus for the research, the Code for Sustainable Homes expresses the requirements for the housing construction sector to deliver better housing by improving the sustainability performance of new homes within specified timescales. The Code extends the framework of existing regulations such as the Building Regulations, central and local government requirements that regulate all house building projects, and any specific parameters that are relevant to individual projects. At the same time as satisfying these, organisations in the housing development sector, operating in market conditions, also need to sustain viable and profitable businesses.

There is considerable uncertainty within this sector on the focus, scope and intrinsic risk of the scale of innovation embedded in the Code. There is an urgent need, therefore, for the innovation implications to both be articulated and explored within a project environment. This will enable sector organisations to channel and optimise their innovation to meet government targets whilst developing new sources of competitive advantage.

1.2.1 The social housing sector

The social housing sector, which includes not-for-profit social landlords (housing associations), local authorities and a range of minor charitable and co-operative organisations, owns and manages about 20% of England's housing predominantly for rent set at affordable levels for households in housing need. The sector is regulated by the Homes and

Communities Agency and is a key policy focus for central government in managing its social goals of the reduction of crime and anti-social behaviour and addressing issues such as community cohesion (Harriott & Matthews, 2004).

Development of new housing for social housing clients is in response to local and national housing need and can be grant-funded by the Homes and Communities Agency. The sector, 'used for design experiments for many years' (Ball, 1999: 13), is thus better placed than the commercial housing construction sector to respond to policy interventions to, for example, develop sustainable housing because of the public funding used to part-finance its construction and the conditional regulatory requirements that grant funding implies.

1.3 Research aim

The aim of the research is to extend and strengthen the theoretical understanding of the links between regulation and innovation for the housing development project sector by using a case study of innovation in the early design stages of a new social housing project designed to meet the Code for Sustainable Homes.

1.4 Research objectives

The research aim will be achieved through:

1 a review and synthesis of construction and relevant associated literature to define innovation, regulations and projects; to consider the nature of the relationship between these; to assess the nature of innovation within housing development projects and to inform the research questions as:

   Research Question One: What is the impact of the Code for Sustainable Homes on the early stages of social housing development projects?

Research Question Two: How do social housing development projects innovate to meet the Code for Sustainable Homes?

2 investigation of the assimilation of the Code in the regulatory landscape of the social housing development project sector;

3 a critical examination of the Code for Sustainable Homes as a potential driver of innovation, reflected in the unit of analysis of innovation to achieve Code level 4.

1.5 Research approach

The research takes an interpretist approach, using a case study to generate data from multiple perspectives on a complex 'real life' situation as a basis for extending theory. Chapter Three of the thesis includes an exploration and defence of this approach as an appropriate methodology for the research subject.

1.6 Research justification

The Code for Sustainable Homes is a recent national voluntary standard (first released in 2008) and, to date, there has been little published academic work which evaluates the response of the housing design and development sector in the development and application of appropriate innovation that satisfies the apparently conflicting drivers of meeting the policy requirement for better homes and of sustaining viable businesses. 'There is a dearth of theorising and empirical data on the Code for Sustainable Homes, which is an emerging regulation whose potential and actual impact has been poorly understood' (Sexton & Abbott, 2009). There have been papers published on the capacity of stakeholders to deliver sustainable buildings, based on case studies of residential, business, industrial and retail developments (Williams & Dair, 2007) and on housebuilders' perspectives on zero carbon housing by 2016 (Osmani & O'Reilly, 2009); neither of these papers focus specifically on the innovation needed to achieve sustainability or zero carbon regulatory targets for

housing development projects, thus the research represents a timely investigation to clarify the explicit and implicit challenges for the innovative capacity of housing development sector organisations to meet the Code's requirements and timescales.

The Code is a major regulation which will have considerable impact on the planning, design, construction and occupation of new homes. The construction sector community has generated assessments (for example, NHBC Foundation, 2008) and practical guidance (for example, NHBC Foundation, 2010). The academic community has the opportunity and capacity for an objective and sustained exploration of the broader issues involved, engaging with practitioners to illuminate the processes of regulation-driven innovation for housing construction projects, and at the same time to extend construction management theory. In focussing on the design phase of the housing construction process, the research illuminates the complex interplay of the Code, as a construction standard, with other equally important design requirements brought to the early stages of the process by other stakeholders such as planning, engineering and highway professions.

1.7 Research contribution

The contribution of the research is the extension of knowledge on the nature of the relationship between innovation and regulation for organisations in project-based sectors, generalising from the findings of a case study of a new social housing design and development project. Research findings will contribute to knowledge on the nature of and response to regulation- and policy-driven innovation. The research will provide insights and information to substantiate future research on the emergent issues that the Code may generate, and on the nature of regulation-driven innovation at project level.

1.8 Research scope

The research uses the Code as a focus for examining regulation-driven innovation, using a detailed analysis of the perspectives of members of an early design phase housing development project team of the business and project process innovation needed to commission, fund, plan and design new homes that meet Code requirements, up to the start of on-site construction within an existing regulatory landscape. The scope of the research does not include technical or supply chain innovation in products that contribute to sustainable housing or, specifically, reduce CO_2 emissions (e.g. solar photovoltaic technology or mechanical heat recovery systems). It complements sector literature on the range of technical and technological developments and accompanying academic research published in more technical journals, for example, Energy and Buildings and Renewable Energy, by illuminating innovation in business processes and project-generated organisational change that is prompted by the Code.

The mandatory territorial extent of the Code is limited to new housing in England. It does not apply in Scotland, and the National Assembly for Wales and the Northern Ireland Assembly adopted Code level 3 for publicly funded housing from May 2008 and June 2008 respectively[2].

The research recognises that the social housing sector is positioned to lead on the construction of new housing to stretching sustainability targets because of its past requirements to meet the EcoHomes standard developed by the Building Research Establishment (BRE) and administered by the Homes and Communities Agency (HCA) who, for their funding cycle 2008 – 2011, specified a minimum Code level 3.

Thus, the research output provides a focus for the experience of the English social housing development sector in working to the requirements

[2] 'The Code' refers to the February 2008 version, relevant to the context of the case study in 2008 - 09.

of the Code within a range of concurrent national, regional, local and project-specific policies and regulations. This is appropriate in that different national responses to the environmental challenges presented by the global response to climate change are generated within specific contexts of governments, institutions, business and legal landscapes (Dewick & Miozzo, 2002; Urge-Vorsatz et al., 2007). Overall, the national construction sector, as a single industry, is a valid subject for analysis because of its shared and specific standards and regulations coupled with customer and client preferences and expectations (Seaden & Manseau, 2001). By using an in-depth multi-perspective case study, this research provides rich detail to extend knowledge on the capacity and capability of the English social housing development sector, as a specific part of the national construction sector, to respond to the regulations governing the sustainable housing agenda against a background of national, regional and local requirements within the contemporary and urgent global context of reducing CO_2 emissions.

1.9 Thesis structure and synopsis

The thesis adopts a standard linear-analytic structure (Yin, 2003: 152), starting here at Chapter One with a description of the issue and the development of the research problem. This is followed with a review and synthesis of relevant literature which informs the development of the research questions in Chapter Two. Chapter Three defines an appropriate methodology for the research, including a justification of the philosophical stance taken, the selection of a single exploratory case study as an appropriate approach for the research problem, a consideration of data collection techniques and a narrative account of the case study. Chapter Four is dedicated to data analysis to answer the research questions and discusses the research findings and implications arising. Finally, Chapter Five concludes the thesis with a critical review of the research, including its contribution to knowledge and suggestions arising for further research.

A full list of references is located after Chapter Five, and relevant Appendices are included at the end of the thesis.

1.10 Summary

This brief introductory chapter provides an overview of the research and outlines the structure of the thesis. Chapter Two provides a detailed literature review and synthesis which informs the development of the research questions.

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Chapter Two: Literature review and synthesis

2.1 Introduction

The review synthesises literature on the three broad themes of the research subject reflected in the title, of regulation as a driver for innovation in housing design projects. The literature referred to is written by academia, industry and government, both general and specific to construction and, particularly, housing construction. Figure 2.1 reflects the framework for the review in the form of an overlapping tri-partite Venn diagram, introducing the three themes of innovation, projects and regulation as linked elements of this research.

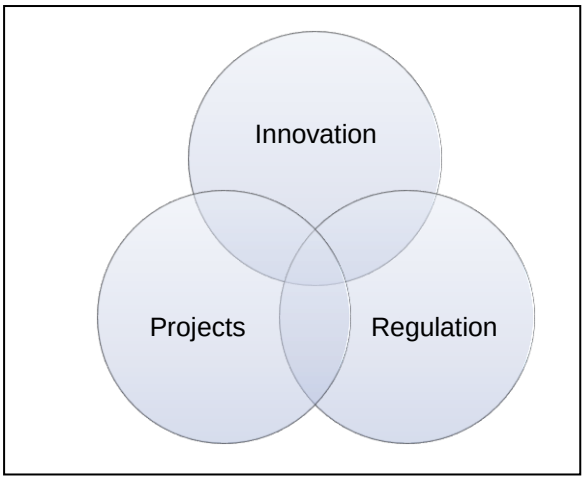

Figure 2.1 Literature review framework

First, each of the elements is explored, using the perspective of a definition that is appropriate for the research and a review of the element in the context of construction, and specifically, housing construction literature. Secondly, relevant literature on the three element pairs is considered; innovation and regulation; innovation and projects, and regulation and projects. Thirdly, the three elements are linked and their themes synthesised to identify perceived gaps in knowledge to justify and validate the research problem. Finally, the research questions are developed and articulated from a synthesis of the literature and located within two relevant models from the literature that capture the research purpose and are used to shape and inform the methodology of the research, the design of the case study and resulting data analysis.

The Code for Sustainable Homes is introduced in detail as part of Section 2.14.1 as a construction regulation.

The literature review begins with definitions and explorations of the three primary research elements of innovation, projects and regulation.

2.2 Innovation

This first section of the review aims to explore definitions of innovation and establish understanding by examining its basic concepts as a foundation for reviewing relevant sections of the literature on innovation in construction, and specifically in housing construction.

The academic research field on innovation is vast, rich and complex and a definition that simultaneously recognises the scale of the field and distils this into a phrase that is appropriate for the research will be proposed. Literature on innovation research covers a broad spectrum of academic disciplines and cross-disciplines including economics, history, humanities, geography, management studies, policy studies, politics, psychology, sciences, science and technology, social sciences and sociology (Fagerberg et al., 2005; Malerba & Brusoni, 2007). The study of innovation is similarly important to industrial practitioners and government policy-makers who generate their own bodies of literature, often in conjunction with the academic research communities (for example BERR & DIUS 2008; DIUS 2008; SCRI 2010).

The richness and complexity of research on the varied aspects of innovation contributes to a 'fuzziness' of basic concepts (Fagerberg et al., 2005) and a 'dissonance' of the language used to describe it (Linton, 2009: 729). Wolfe (1994) notes that the extent of the literature indicates the complex and context-sensitive nature of innovation, and the various perspectives of research subjects and sectors will inform both definitions and applications (Linton, 2009; Abernathy & Clark, 1985).

The breadth and richness of innovation itself is matched by parallel research to propose theoretical frameworks in order to better understand its complexities. The instability of the 'extreme variance' (Downs & Mohr, 1976: 700) of findings (where some variation is acceptable for social science research) that do not contribute to a cumulative body of knowledge on innovation is noted, a lack of clarity of the conceptual issues is identified and research to consolidate and generate a general theory of innovation is proposed. Wolfe (1994), however, argues that a single theory of innovation that is relevant across the spectrum of academia, industry and government is unhelpful and unattainable and, in order to be meaningful, innovation research must state and clarify its specific focus of study to contribute 'cumulative and comparable' research to extend existing relevant theory (Wolfe, 1994: 406). Thus a definition of innovation, informed by a reflective literature review based on a clear understanding of its basic concepts, is proposed and justified as unambiguous and capable of supporting a meaningful contribution to the appropriate branch of innovation study.

2.3 Definition of innovation

A useful starting point is to extract and consider key elements of definitions from relevant literature. Table 2.1 records these in chronological order, notes their justification for inclusion in the table and informs a provisional definition as a basis for extending the literature review to support a sound general understanding of innovation.

Table 2.1 Definitions of innovation

Definition	Reference	Justification
'the creation of new combinations of existing resources'	Schumpeter (1934)	The economist and social scientist Joseph Schumpeter is 'considered a pioneer in the economic analysis of innovation' (Pavitt, 2005: 87 and others) and characterised as the 'godfather' of innovation studies (Tidd et al., 2005: 7 and others).
'any idea, practice, or material artefact perceived to be new by the relevant unit of adoption'	Zaltman et al. (1973)	This emphasises newness or novelty as a key aspect of innovation (in Johannessen et al, 2001: 22).
'the actual use of a nontrivial change and improvement in a process, product or system that is novel to the institution developing the change'	Slaughter (1998: 226, from Freeman, 1989)	'Within the construction industry, the definition provided by Slaughter is broadly accepted by participants and academics' (Blayse & Manley, 2004: 144).
'the effective generation and implementation of a new idea, which enhances overall organisational performance'	Barrett & Sexton (1998: 2)	This definition, developed as part of research in innovation in large construction firms, was considered appropriate by small firms in subsequent work.
'application of technology that is new to an organisation and that significantly improves the design and construction of a living space by decreasing installed cost, increasing installed performance and/or improving the business process'	Toole (1998: 323)	This relates specifically to technological innovation in housing construction and identifies the innovation outputs of improved cost, performance and processes.
'the successful exploitation of new ideas'	Department of Trade and Industry (2003a: 8)	The UK government's definition of innovation, originally generated by the Department of Trade and Industry.
'a process of turning opportunity into new ideas and of putting these into widely used practice'	Tidd et al. (2005: 66)	The authors support their definition with extracts from a range of research.
'the recognition of opportunities for profitable change and the pursuit of those opportunities all the way through to their adoption in practice'	Baumol (2002) in Francis & Bessant (2005: 171)	This reflects notions of profit as a result of following ideas through development to application.
'a continuous and dynamic process in which ideas are transformed into value'	(Confederation of British Industry / QinetiQ, 2008: 9)	The CBI definition includes value as a specific output of innovative activity.

'the successful exploitation of new ideas to obtain competitive advantage'	DBIS (2008: 18)	The Department for Business, Innovation and Skills' Strategy for Sustainable Construction aims to clarify the policy framework for the sector and includes a chapter on innovation.
'the successful introduction of new services, products, processes, business models and ways of working'	ESRC (2008: 2)	The Economic and Social Research Council extends the definition of innovation to specify business models and ways of working.

The range of definitions from the various perspectives noted in Table 2.1 supports the concept that 'there is no generally accepted definition of innovation at the present time, however there has been a noticeable convergence as to its principal characteristics' (Seaden & Manseau, 2001:185). The principal characteristics of the definitions in Table 2.1 are extracted to form a composite and provisional summary of innovation as 'the successful application of a new idea that generates value' and its elements are considered below:

- 'Successful application' implies the recognition and use by a customer population. The original innovative idea needs to be successfully applicable or implementable within a business context, thus differentiating invention from innovation, where innovation = invention + exploitation.

- 'New idea' recognises that an idea is the starting point for innovation (Thompson, 1965) and its relative newness, or novelty, is valid at the levels of the firm, the market or the world. At the level of the firm, newness, or significant improvement, can be either newly developed by the firm, or adopted from outside (OECD & SOEC, 2005). The concept of relative newness or novelty is a key aspect of much innovation literature.

- ‘Generation of value’ is achieved in economic terms by increasing profit, profile or competitive advantage at firm or business sector level (Kimberley, 1981), and in broader terms, in a societal and cultural context, by contributing to the well-being of current and future society (Barrett, 2008). However, not all improvements in performance that generate an increase in value can be defined as innovative. The OECD lists changes which are not considered to be innovative (even if they improve performance) as part of their guidance for the measurement of innovation and these are noted here as an additional aspect of the definition of innovation. Stopping an activity (such as the use of a process or a marketing method or stopping product manufacture), replacing or extending equipment, revising a business model because of changes in factor pricing, regular, cyclical changes or the distribution of new or improved products are not considered innovation (OECD & SOEC, 2005).

2.3.1 Value in construction

The definition of innovation in the context of construction raises an interest in the inherent value of construction. First, both the verb ‘to construct’ and the noun ‘construction’ are in common use, reflecting both the act of construction (which is temporally limited) and the finished product (which is permanent, or at least long-term). The generation of value during the act of construction (as the production of the built environment), is one of three facets of production. The other two are proposed as a transformation and as a flow of work (Bertelsen & Koskela, 2004). Value is generated in the early stages of the design stages as a learning process between the client and the design professionals, in which the client’s ‘value parameters’ are realised through the design (Green, 1996).

Barrett (2008) notes two definitions of value in construction that are applicable, first to the value of the act of construction and secondly to the value of the finished product. First, the basic economic definition, based

on Standard Industrial Classification (SIC)[3] section F45 lists 28 activities (ONS, 2009: 39) associated with construction including site preparation; civil engineering, building of completed constructions; rental of equipment, which represents value (in the form of income) to contractors and contributes (via the SIC) to the consistent measurement of national, EU and global wealth generation i.e. income. Secondly, the value-added aspect of construction is noted, defined as 'a change agent for the creation, development and maintenance of the built environment so that it supports the quality-of-life....requirements of society' (Barrett, 2008: 11), a view developed as a 'meso-economic' analysis of construction, reflecting not only the physical process of construction as the production of the built environment, but also the industrial structure, political and policy context and the influence of groups such as professional associations, trade unions and, ultimately, end users. Specifically for social housing, the commitment of the government to support the construction of 50,000 affordable homes a year by 2010 (DCLG, 2007a) is assessed as a 'key driver of ... economic and wider well-being' (Feinstein et al, 2008: 12).

It is useful to consider a meso-economic approach to the value of social housing for this research, where the linked themes of innovation in development projects and of regulation for sustainability in housing as an end product owned by the housing association client and occupied by rent-paying tenants, reflect a socio-economic conceptualisation of the research problem and its context.

2.3.2 Innovation and innovations

The literature reviewed and the resultant provisional definition of innovation reflect the predominant understanding of innovations (plural) as

[33] 'The United Kingdom Standard Industrial Classification of Economic Activities (SIC) is used to classify business establishments and other standard units by the type of economic activity in which they are engaged. It provides a framework for the collection, tabulation, presentation and analysis of data and its use promotes uniformity' (ONS, 2009: 1).

objects, artefacts or processes that can identified and quantified as a way of assessing the success of an organisation, sector or national economy. This is in contrast to innovation (singular) as a behaviour (Wolfe, 1994) or a 'complex recursive reality' (Sexton & Abbott, 2009: 3). The definition of innovationas 'the development and implementation of new ideas by people who over time engage in transactions with others within an institutional order' (Van de Ven et al, 1999: 590) shifts the focus from the end result onto the process of the generation of a new idea. Sexton and Barrett (2003) note that innovation literature is clustered around two models of the process of innovation: rational, which defines a linear, 'organised, systematic and rational' (Drucker, 1986: 40) process with defined stages of conception, refinement, testing and application; and behavioural, describing an alternative, non-linear progression of 'divergent and convergent activities' (Van de Ven, 1999:16) of those involved.

The definition of innovation proposed for the research is thus extended to reflect the process of innovation as shared and dynamic, as 'the process of the successful application of a new idea that generates value'. The research focuses on the capacity of project teams to work together to innovate to meet the Code for Sustainable Homes, illuminating innovation as a process with an end result, and using the singular of 'innovation'.

2.4 Definition of innovation - summary

Having introduced some of the key concepts of innovation in a definition constructed from elements of selected phrases as 'the process of the successful application of new ideas that generate value', the literature review continues with a consideration of the typology of innovation as a means of identifying and illuminating the range and nature of innovation that may be required to meet the Code for Sustainable Homes.

2.5 Innovation typology

Downs and Mohr (1976), in noting the instability of innovation theories, suggest that innovation as a generic heading for research is not helpful, and that the adoption of categories or typologies is useful, based on the characteristics or attributes of the innovation being studied. First, a generic overview of the typologies of innovation according to characteristics, attributes and effects is noted to inform and support an exploration of innovation that has been identified within the construction sector.

There are two distinct yet balanced ways of referring to innovation in terms of a position on complementary axes or dimensions (Tidd et al, 2005) representing the category and scale of innovation. First, the typology ('a classification according to general type' (Oxford Dictionaries Online)) of category of innovation describes a new, changed or improved entity, usually an artefact, a process, a system or a business model, and the literature establishes a consistent and coherent framework as a prelude to an exploration of the second typology which expresses the scale or extent of change to and impact on the status quo.

2.5.1 Innovation typology - category

The first dimension of the typology of innovation classifies innovation according to category, starting with innovative products and processes. Subsequent to these, literature diverges to describe, for example, 'new sources of supply, the exploitation of new markets and new ways to organize business' (Fagerberg, 2005:7). These and other variations and extensions are tabulated at Table 2.2 as a preface to exploration of the categories of innovation in common use.

Table 2.2 Typologies of innovation category

	Francis & Bessant, 2005	Schumpeter noted in Fagerberg et al. 2005)	Dosi, 1988	Edquist et al., 2001	OECD, 2005
1	Product	New products	New product		Products: Goods Services
2	Process	New methods of production	New production process	Technological process Organisational process	Processes
3		New sources of supply			
4	Position	Exploitation of new markets			Marketing
5	Paradigm	New ways to organise business	New organisational set-ups		Organisational

Table 2.2 summarises four broad categories of innovation category, described as product, process, position and paradigm (Francis & Bessant, 2005). Schumpeter's typology of five categories includes 'new sources of supply', however this has not developed as a contemporary innovation category and is not reflected in recent literature. Carland et al. (1984) note that Schumpeter's original definition of 'an enterprise that introduces a new combination such as the opening up of new sources of supply of material' is ambiguous. In addition, this may reflect the 1930's origin of this innovation category in an industrial era which relied on material supplies, when a new supply source would have generated significant value. The four categories of innovation in common, current, use are explored below and examples from each are included.

2.5.1.1 Innovation category - product innovation

Product innovation is commonly identified as the lower tier of innovation category noted in Table 2.2 and describes the introduction of new or significantly improved physical objects. Significant improvements include 'technical specifications, components and materials, incorporated software, user friendliness or other functional characteristics'. Definitions of product innovation either include innovation in services, for example 'the

introduction of a good or service' (Edquist, 2005), or distinguish innovation in 'material goods' from innovation in services where there is no physical product as the outcome of traditional 'research and development' activity (OECD, 2005). An example of new product innovation is the original yellow rectangular Post-It notes, developed by 3M in the US, and an example of a significantly improved product is the extension of the range of shapes, sizes and colours (Nohria & Gulati, 1996 and others). An example of a new service might be on-line university registration for students, and a significant improvement to this service would include the capacity to check and amend centrally-held personal details as part of the process.

2.5.1.2 Innovation category - process innovation

The introduction or improvement of products, or services, (for example those noted above in 2.5.1.1) implies parallel developments (either new or improved) to the processes of their production or delivery, and these represent the second level of the typology of innovation categories noted in Table 2.2. A process can be defined as a sequence of activity with an input, a process of transformation process and an output (Francis & Bessant, 2005) and improvements may include changes to techniques, equipment or software (OECD, 2005). Process innovation can be separated to distinguish technological and operational processes (Edquist, 2005) where a technological change to a process is characterised as a change in physical equipment and an operational change is organisational, associated with the way work is carried out. Examples of process innovation include Fordism as series of standardisations of the production of early Ford cars in America, and lean (emerging from Toyota's 'just in time' production methodology in Japan) as an operations-based project delivery system to manage construction (Fagerberg & Godinho, 2005; Howell & Ballard, 1999).

2.5.1.3 Innovation category - position innovation

The exploitation of new markets noted by Schumpeter (1934) involves the re-positioning of an existing product, brand or firm and is included as part of the typology of innovation category because the process of positioning reflects the elements of innovation. This level of innovation relies to a certain extent on the expertise and skill of marketing and advertising, and examples include the emergence of 'New Labour' in the 1990s and, at product level, Lucozade as a drink for health rather than convalescence, the Daily Mail as a 'women's' newspaper and Manchester United as a global, and globally recognised, brand (Francis & Bessant 2005). An historical example of the exploitation of new markets is the original publication of Penguin books in 1935, whose content and distinctive presentation were aimed at the appetite of 'the vast reading public for intelligent books at a low price' and were widely available for the price of cigarettes in stations, tobacconists and chain stores at a time when paperback books were either expensive or of poor quality and thus 'the way the public thought about books changed forever' (Penguin Company History).

2.5.1.4 Innovation category - paradigm innovation

Innovation in the organisation of business describes a fundamental shift in the 'underlying mental model' or the 'organisational orthodoxy' or paradigm, where 'paradigm', in business management literature, is a description of a new way that replaces an older, more traditional way. It involves learning and self-reflection and can be 'inner-directed' with shifts and changes in values and power structures, or 'outer-directed', with re-configured business models following, for example, acquisitions, mergers and alliances, with the ultimate aim of generating and sustaining increased value. (Tidd et al., 2005: 11). The classic example is Henry Ford's change to the car, from a hand-crafted low-volume item to a mass-produced, cheap, and accessible product, thus fundamentally changing the market and its associated infrastructure (e.g. fuel, roads). More recent examples

include low-cost airlines with associated increases in and management of, for example, air traffic, aircraft production, and destination infrastructures.

2.5.2 Summary of innovation typology - category

The innovation categories used for the purposes of this research are the '4 P's of innovation' - product, process, position and paradigm (Francis & Bessant, 2005) noted in Table 2.2 because of their clarity and potential relevance for the housing development and construction sector as it adapts to the requirements of the Code for Sustainable Homes. Although the introduction of the '4 P's of innovation' implies a neat demarcation between them, the literature emphasises the complex and evolving nature of innovation in category, particularly for novelty and change in products and processes. Innovation does not happen in a vacuum, it 'is a process not a single event' (Tidd, 2005: 87) and organisations cannot innovate in isolation. Chesborough's concept of 'open innovation' (Chesborough, 2003) underpins much recent research on innovation, based on the premise that organisations need to look both internally and externally to generate innovative ideas, and this focuses on 'the permeability of firms' boundaries' (Dahlander & Gann, 2010: 699) where people, ideas and resources flow into and out of organisations. This is characterised as a positive situation, and, for the research, emphasises the potential exploitation of the benefits of 'open' innovation within project environments.

2.5.3 Innovation typology - scale

The second dimension of the typology of innovation describes the degree of novelty of innovation (in product, process, practice or paradigm, as introduced above) compared to the current practice (Henderson & Clark, 1990) or 'state of the art' (Slaughter, 1998) and the extent to which the innovation affects or has an impact on linked or associated components and systems, where these links and associations may be specific to the organisation and/or external, impacting on and acting as drivers for

innovation in associated organisations. First, this section introduces the basic characteristics of incremental and radical innovation. Secondly, it considers Henderson and Clark's seminal paper (1990) which extends this dimension of scale to include architectural and modular innovation. Thirdly, the notions of 'steady state' and 'beyond steady state' innovation are contrasted to provide a conceptual background for the research questions on the capacity of sector organisations to generate innovation to meet regulatory requirements. Finally, the 'hypercube' of innovation (Afuah & Bahram, 1995) is considered as a model for describing the potential impact of innovation across organisations as a preface to the introduction of the Complex Product System model as an alternative, and more appropriate, framework for innovation in construction.

2.5.3.1 Innovation scale - incremental and radical innovation

Incremental and radical innovation are described at the opposing ends of a scale and are considered and contrasted. Incremental or marginal innovation is a minor change or improvement to something that already exists. Incremental product innovation optimises 'the potential of the established design' (Henderson & Clark, 1990: 9), or adjustments and 'system tweaks' to develop or extend technological or organisational processes (Daft, 2007; Dewar & Dutton, 1986). Although minor and commonplace, the cumulative value of incremental innovation can be considerable (Tidd et al., (2005), noting Hollander's classic 1965 study of Du Pont rayon production). Incremental innovation occurs through established management structures and normal business processes, and maintains the equilibrium or status quo, affecting just the innovating part of the organisation (Daft, 2007) and reinforcing overall organisational capabilities (Henderson & Clark, 1990).

Incremental innovation is in contrast to radical innovation that, at an organisational level, has the capacity to transform, or even overturn, the status quo. It requires a fundamental shift in perspective and is

characterised by Schumpeter's notion of 'creative destruction' [4] describing a breakthrough in science or technology that can change the nature of an industry. Incremental and radical innovation occur at opposite ends of a scale, or axis, that describes the degree of novelty involved in products, processes, position or paradigm (where these are the categories of innovation, as discussed above, Section 2.5.1).

Dewar and Dutton (1986), noting the incremental / radical continuum (originally defined by Hage,1980) argue that the position of an innovation on the incremental / radical continuum depends on 'perceptions of those familiar with the degree of departure of the innovation from the state of knowledge prior to its introduction' (Dewar & Dutton, 1986:1423), thus innovation is in the eye of the beholder, or at least of the innovating organisation. For example, the introduction of an advanced network system in a multi-national organisation may be assessed as incremental, whereas the first connection of a personal computer to the internet would be considered as radical for a small firm (Tidd et al., 2005). Figure 2.2 compares incremental and radical innovation.

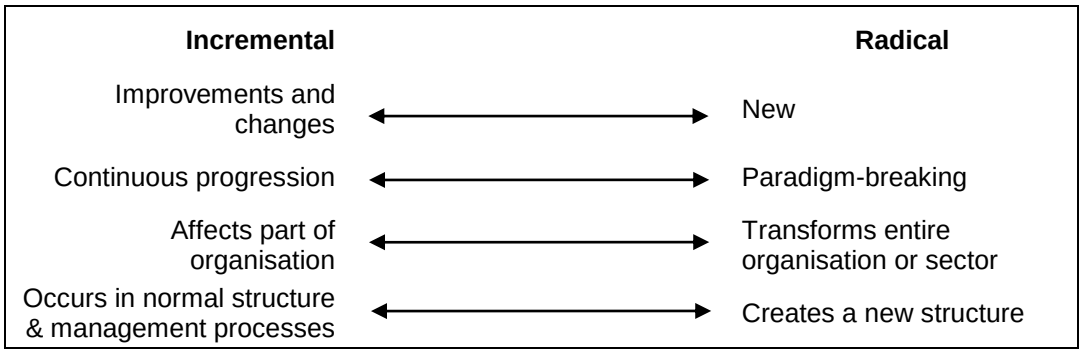

Figure 2.2 Comparison of incremental and radical innovation (adapted from Daft, 2007: 280)

[4] Schumpeter (1936) described the implementation of new ideas that change established procedures and alter organisational practices as 'the gale of creative destruction' (Bercovitz & Feldmann, 2007).

2.5.3.2 Innovation scale - modular and architectural innovation

The scale of incremental and radical innovation is extended with Henderson and Clark's (1990) significant contribution to the typology, and understanding, of innovation. This identifies the links between innovation in the components or 'modules' of a product or service and the effects of such innovation in the product or service 'architecture', as summarised in Figure 2.3.

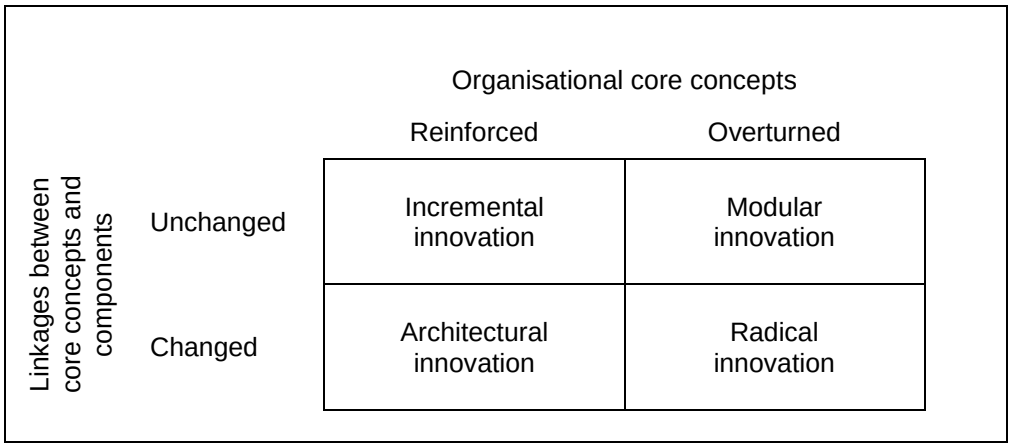

Figure 2.3 A framework for defining innovation (Henderson & Clark, 1990)

As noted above (Section 2.5.3.1) incremental innovation reinforces core concepts and does not change or alter links to related products or processes. Radical innovation overturns organisational core concepts and changes links to related components. A modular innovation describes a significant change in a discrete component that has minimal or no effect on related products and processes and thus is relatively self-contained. In contrast, an architectural innovation describes any change in a component that involves major changes to related components and systems, extending to other organisations involved in the process (Slaughter, 1998). This is a key point in the literature review as it recognises that innovation does not occur in a solipsistic organisational vacuum, and provides a conceptual background for the research focus on organisations working together on projects.

2.5.4 The 'hypercube' of innovation

Using Henderson and Clark's model (at Figure 2.3), the 'hypercube' of innovation (Afuah & Bahram, 1995) further defines the complex and multi-dimensional effects of innovation by identifying the potential impact on the competence for response in associated organisations, where the impact of innovation on the 'innovating entity' can affect the assets or activities of customers and suppliers, which has particular relevance for innovation within the context of projects. Afuah and Bahram take product innovation as a unit of analysis and the basis for the hypercube model, at Figure 2.4 showing the consequent relationships arising from innovation between a range of organisations as multi-dimensional, and this provides a useful tool for assessing the potential impact of innovation to meet the Code for Sustainable Homes at project level. The hypercube extends the focus of innovation from the 'innovating entity' to customers, in terms of the adaptation of their own capabilities; to complementary innovators, for example the development of software associated with, and in conjunction with, advances in computer hardware; and to suppliers of components and equipment that contribute to the realisation of the original product innovation.

The 'hypercube' model at Figure 2.4 captures the inter-organisational impact of innovation that is of relevance to project-based working, and adds value to the aim of the literature review to generate an understanding of innovation. However, the Complex Product System model of innovation introduces a perspective on the project itself, rather than the organisations within the project, and is shown to be more appropriate to this research, as discussed in Section 2.8.3.

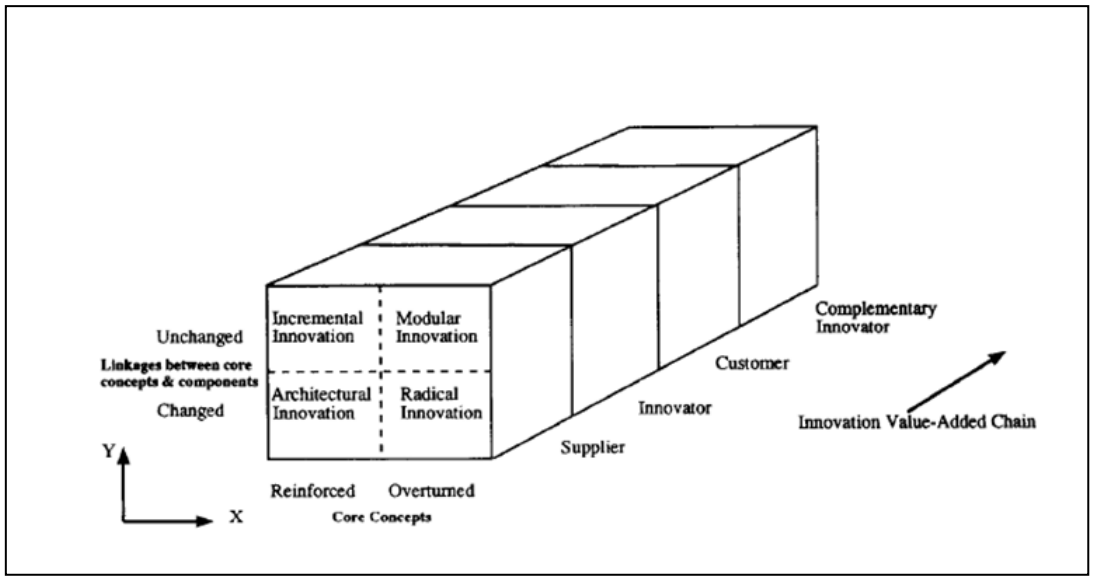

Figure 2.4 The hypercube of innovation (Afuah and Bahram, 1995)

2.6 'Steady state' and 'beyond the steady state' innovation

In addition to the typologies of innovation category and scale discussed above, an extra dimension is useful for this research, adding further depth and understanding to the nature of innovation, particularly in the context of construction innovation. First, 'steady state' innovation is introduced, followed by a differentiation of disruptive and discontinuous innovation as accounts of innovation 'beyond the steady state'.

2.6.1 Steady state innovation.

'Steady state' describes incremental innovation whose impact is usually predictable within a limited range, and effects on relationships with other products, processes and systems are likely to be minor (Slaughter, 1998; Abernathy & Clark, 1985). This flow of incremental change in an established framework (Tidd et al., 2005; Hyland & Boer, 2006; Daft, 2007) of 'dynamic stability' (Freeman, 1991) can be described as 'doing what we do, but better' (Tidd et al., 2005: 73). Henderson and Clark (1990) define this normality of developed, embedded routines and structures as the 'architecture' of organisations acting within a sector context where the normalised 'rules of engagement' exist and are recognised and applied. 'The dogged pursuit of improvement' (Abernathy & Clark, 1985: 116) is

easy to manage and resource because the associated risk factors are smaller and less inherently uncertain (Tidd et al., 2005).

2.6.2 Innovation 'beyond the steady state'

In addition to non-steady state innovation described as radical and architectural, as identified by Henderson and Clark (1990), disruptive and discontinuous innovation are also identified in the literature. Although their impact is similar, their characteristics are differentiated.

2.6.2.1 Disruptive innovation

The influential work of Christensen (1997) identified the emergence of new markets, rather than advances in technology, expressing a range of new or different demands and expectations as a trigger for innovation. Emerging and evolving demand enables new firms to innovate to meet such demands, which results in a temporarily disrupted or fractured market landscape as these new firms establish themselves in the changing mainstream market. The Innovator's Dilemma (Christensen, 1997) refers to the challenges of managing steady state innovation whilst responding within a disrupted market (Tidd et al., 2005). Christensen's model focuses on innovation at the level of the firm and its impact on the market, and so its direct relevance for this research on project innovation in response to regulation is limited.

2.6.2.2 Discontinuous innovation

Disruptive innovation is a specific aspect, identified as market-driven, of a broader spectrum of discontinuous innovation that can arise from shifts in technological, political and other frontiers (Francis & Bessant, 2005) where improvements to products and services change the rules and reframe the normal business 'space' in a process of 'creative destruction' originally identified by Schumpeter. 'Creative destruction' summarises the Schumpeterian model of innovation, where firms develop or improve

products, and the processes and technologies which produce these become the new industry standards. The market thus evolves 'from within', driven in a dynamic 'demand–pull' pattern (Clark & Juma, 1988).

However, of particular relevance for this research is that one of the potential triggers for discontinuous innovation is identified as a 'shift in the regulatory regime' (Tidd et al, 2005: 35) arising from a change in the political agenda, specifically the increasing knowledge of and evidence for new housing's contribution to CO_2 emissions as part of the response to the general emergence of the national, European and global sustainability agenda, as outlined in the research background at Section 1.2. In the context of housing, demand for innovation is generated by a range of sector organisations working to meet a range of existing and new regulations within a market that tends to be driven by low price rather than desire for new and improved products or components (Barlow, 1999).

2.6.3 Innovation beyond the steady state - summary

The brief summaries noted in Table 2.3 provide a useful and coherent account of the characteristics of and responses to the four aspects of innovation 'beyond the steady state' to be generated by the housing development sector to meet the requirements of the Code for Sustainable Homes. This innovation goes beyond the development of new or improved housing components by anticipating the potential problems and consequences of innovation that requires changes to organisations' internal architecture and to the ways in which organisations work together.

Table 2.3 Innovation 'beyond the steady state'

Term	Summary	Key literature
Disruptive	Prompted by evolving market demand and resulting in a disrupted market.	Christensen (1997)
Discontinuous	In response to a range of external triggers, needing different approaches to organisation and management of innovation.	Abernathy & Clark (1985)
Architectural	Impacts on the inherent culture and behaviour of a firm and can have negative business results because of a failure to fully manage the change.	Henderson & Clark (1990)
Radical	Affects not only the 'innovating entity' but also associated firms and sectors.	Ettlie, Bridges & O'Keefe (1984)

2.7 Innovation - summary

The typologies of innovation category and scale have been noted to encompass the notion of the extent of change from the current position or 'state of the art' as a way of assessing and managing innovation impact at intra- and inter-organisational levels. The notion of steady state innovation has been noted and contrasted with innovation 'beyond the steady state', as an ideal for the innovation needed by the housing design and development sector to meet the Code for Sustainable Homes as part of the regulatory landscape. However, innovation within the construction sector is assessed as predominantly incremental and thus there is an apparent mismatch between the implicit innovation vision in the Code and the sector's capacity for an appropriate response. Section 2.8 reviews the relevant literature.

2.8 Innovation in construction

There are two relevant points that emerge from literature on construction innovation that are critical to the research problem. First, the characterisation of construction as a low-level innovator, within which housing construction is particularly identified as low-level, is explored, and secondly the alternative Complex Product System (CoPS) model of innovation is argued to be more appropriate than the firm-based and -

focused genre of general innovation literature discussed above, as a framework for the analysis of the Research Questions.

2.8.1 Construction as a low-level innovator

The description of 'steady state' innovation at product level noted in Section 2.6.1 above characterises the construction sector, described as an example of a generator of low level innovation (Rutten et al., 2009) and as low tech, traditional, conservative, risk-averse and supplier-led (Reichstein et al., 2008). In the broad context of innovation study, construction is viewed as low level and lacking the drivers, capacity or need to innovate at anything more than product and process level, and this is unlikely to generate the change needed to achieve zero-carbon homes from 2016 as required by the Code for Sustainable Homes. An alternative view focuses on the unreported or 'hidden innovation' of the construction sector, (NESTA, 2007) in comparison to standard sectoral reporting (Winch, 2003). This perspective struggles to find a foothold in the broader construction innovation research landscape, but suggests that the housing construction sector is able to innovate to meet stretching sustainability targets.

2.8.2 Innovation in housing construction

Within the context of the broader field of construction innovation, housing construction has the reputation of being even less innovative. This premise is explored in the context of accelerating innovative ways of working to deliver regulation-driven sustainable housing. The reasons for this reputation are characterised as the economic failure of the mass production of housing (Winch, 1998), the certainty of profits for developers guaranteed by house price inflation such that innovative strategies are not required and the diffused nature of development firms making it difficult to establish ownership and benefits of any incremental, low level, low risk product innovations (Barlow, 1999).

There is a gap between the capacity to innovate and experiment by housing associations and local authorities as clients of the house building sector (Gann, 2003), and the demand for such innovation by homeowners as consumers who tend to want more traditional housing (NHBC Foundation, 2008). 'Housing design, particularly in Britain, has been highly conservative. This is partly because of the role of housebuilders as, primarily, land developers, making profit from speculation rather than innovative design and production... It is difficult for consumers to be other than conservative given the limited choices available and the restrictions imposed by the cost of housing' (Madigan & Milner, 1999: 408).

Responding to the significant regulatory requirement for sustainable housing, as a 'doing what we do but differently' prompt, can generate not only the physical changes to the supply chain components and the finished product, but also to new ways of working that enable the housing development and construction sector to move away from the 'low level innovator' label and reputation described by (for example) Rutten et al., (2009) and Reichstein et al., (2009). Ball (1999) notes three constraints on housing innovation as conservative client preferences, restricted lending practices and a cyclical market but points out that these should not be an excuse for stagnation, and it is within this context that the housing design sector needs to respond to the Code for Sustainable Homes.

2.8.3 Housing construction as a Complex Product System

It is noted (Seaden & Manseau, 2001) that the predominant model and theories of innovation from the perspective of firms innovating at product and process level are not appropriate for construction which has site-specific production, a long product cycle (Winch & Courtney, 2007) and involves a network of firms (Winch, 1998) or organisations. An alternative Complex Product System model (CoPS), originally proposed by Miller et al. (1995) in the context of the flight simulation industry, is shown to be

more relevant to innovation in the construction sector, and this is explored here to justify it as a framework for the research.

The CoPS model has distinctive characteristics of many interconnected and customised elements, non-linear and continuously emerging properties, where changes in one element can generate changes in other parts of the system, and a high degree of user involvement in the process (Winch, 1998: 269). Complex products and systems are identifiable in a range of firms and sectors and their role in these industries has recently become the subject of systematic research. CoPS can be defined as 'high cost, engineering and information-technology intensive, customised products having large numbers of tailored subsystems and components. Examples of CoPS include aircraft, military systems, constructed facilities, offshore oil platforms....and many other heavily engineered systems' (Hansen & Rush, 1998: 555). CoPS are not mass-produced in terms of either product or process (at the lower end of the innovation category scale) and 'tend to be business-to-business products, developed and produced on a project basis through multi-firm alliances' (Hansen & Rush, 1998: 555) where single end products are customised with multiple components and technologies (Rutten et al., 2009). Specifically in terms of innovation, construction is noted as a 'complex area involving numerous agents and interactions in the development and adaptation of innovation' (Seaden & Manseau, 2001: 184).

There is evidence of these characteristics in the housing development and construction sector, where a 'volume production model' is neither applicable nor has been successfully applied in client-driven, site-specific projects (Winch, 1998). Although Hobday (1998) notes that the routine construction of housing does not merit a CoPS innovation model, the development of housing to meet the significant new standards required by the Code for Sustainable Homes, and therefore not 'routine', justifies this approach and is appropriate for the research. It is therefore useful to

consider the innovation evidenced in this research from a CoPS perspective, where changes in one part of the system affect or impact on the design, construction or operation of other parts, reflecting the literature on the 'hypercube' of innovation (Afuah & Bahram, 1995) noted in Section 2.5.4. The process of innovation for CoPS requires techniques that are different to those for managing innovation in mass-production firms (Hansen & Rush, 1998; Gann & Salter, 2000) with 'close interactions and negotiations between a relatively small number of key players' (Seaden & Manseau, 2001: 189). The recognition of negotiations between project members foreshadows conclusions arising from analysis of research case study data around meeting the range of regulations associated with the early stages of housing design.

Miller et al's 1995 model has been adapted by Winch (1998) in relation to the construction sector and is reproduced at Figure 2.5.

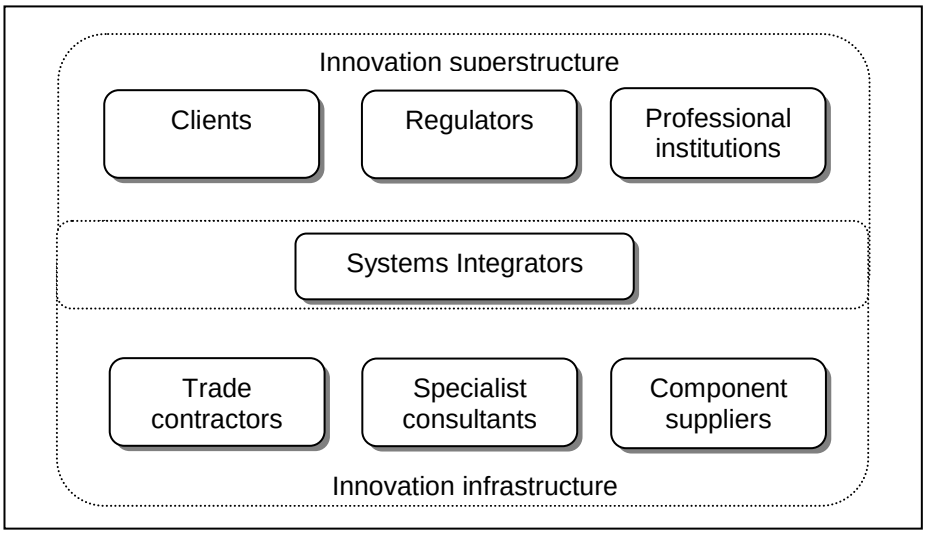

Figure 2.5 Innovation structure in CoPS industries (adapted from Winch, 1998)

The role of regulators within the Complex System model is explicitly included, recognising the integral function of regulation within the sector. Winch notes the regulatory regime as the technical regulations 'aimed at assuring the integrity and performance of the constructed product' rather than the 'socio-economic regulations of what is built where' (Winch,1995:

271). However, although the Code for Sustainable Homes is identified as a regulation using Winch's definition, the analysis of research case study data also extends regulation to include the 'socio-economic' planning and design requirements of the local authority and county council which exert a similar amount of traction as the technical regulations in the early design stages of the research case study project. Additionally, the Homes and Communities Agency, as providers of grant finance for the case study development project, fulfil a regulatory role within the Complex Product System model, bringing a series of sustainability, financial and timeframe requirements to the project via the housing association client, which are seen to generate additional constraints within the project. Thus the technical regulation accommodated within the CoPS model, for the purposes of the research, is extended to include the socio-economic regulations that surround the early stages of new housing design.

2.9 Innovation in construction - summary

Having explored the nature of innovation in terms of product, process, position and paradigm, introduced the extremes of incremental and radical innovation and extended this with a consideration of the impact of innovation on the innovating and associated firms and their sectors, innovation in construction, and specifically housing construction, is assessed as predominantly incremental for a series of reasons. The Complex Product System model provides an alternative perspective for innovation taking place across a number of organisations and this will be identified and justified as an appropriate framework for analysis of the Research Questions. The next section of literature review focuses on projects, as the second of the three key elements for this research.

2.10 Projects

This section of the literature review generates a definition of project that is appropriate for this research by exploring the nature of construction projects and their key participants. It considers the relatively un-

researched area of the early stages of construction projects and justifies this as a context for the case study.

2.10.1 Definition of project

A review of relevant literature was carried out to generate a definition of project for this research, from which two observations were provoked. First, definitions from both construction and general project management literature tend to focus on the management of projects and define 'project management' as their subject of study (e.g. Bresnen, 1990; Morris, 1994; Walker, 2007; Winch, 2010); and secondly, construction project management is considered from the perspective of firms, primarily the contractors, involved in projects (e.g. Gann & Salter, 2000; Keegan & Turner, 2000; Acha et al., 2005). A definition of project for the research seeks to reflect two elements; first, the passage of time because projects, and organisations' involvement in them, are limited; and secondly, a primary perspective on the project itself, rather than on the firms involved, and these are explored below.

Definitions of 'project' that are an integral part of definitions of 'project management' within the literature are not helpful, and so the distinction made by Munns and Bjeirmi (1996), which explicitly separates the project from its management, is welcomed. Munns and Bjeirmi define a project as 'the achievement of a specific objective which involves a series of activities and tasks which consume resources....which has to be completed within a set specification, having definite start and end dates' (Munns & Bjeirmi 1996: 81). This definition captures the 'project' as a dynamic sequence of events and thus satisfies the first criterion, to reflect the passage of time.

Secondly, this research relies on a clear definition of the project itself that is not aligned with, or from the perspective of, any particular organisation.

Two helpful project definitions have been identified in the literature, as follows.

2.10.1.1 Projects as temporary organisations

Turner (2006) defines a project as 'a temporary organisation to which resources are assigned to do work to bring about beneficial change' where the temporary organisation is disbanded when the project is complete (Turner, 2006: 1). The model of projects as 'temporary organisations' has been adapted and extended in Austrian and Swedish project management literature, however the concept of a single organisation implies not only a common goal but also shared drivers, and the research case study participants expressed a range of different (yet complementary) reasons for involvement in the project. Bresnen (1990), although writing from the perspective of a project-based firm, recognises the 'network of interaction' of construction projects and observes Cherns and Bryant's (1984) characterisation of a project as a 'temporary multi-organisation' (Bresnen, 1990: 37), Hobday notes, in the context of the delivery of Complex Product Systems (such as construction), 'temporary project-based organisation[s] involving many firms' (Hobday, 1998: 260) and Slaughter notes 'a temporary alliance of disparate organisations' (Slaughter 1998: 27).

2.10.1.2 Projects as formal groups of firms

The project-based work of the construction sector is defined as complex, including links and relationships between diverse firms and organisations involved in varying degrees at the various stages of the development and construction process (Seaden & Manseau, 2001; Blayse & Manley, 2004). The involvement of firms is supported by Turner's (2006) definition of a project as 'a temporary nexus of contracts' to express the nature of the formal relationship between project participants. The contractual basis of a project, where a contract is a formal, legal entity involving offer, acceptance of offer and (usually financial) consideration (Business Dictionary Online) is applicable in the build stage of a project where

construction is carried out by contractors for a client. At the early, design stage of a project, formal contractual arrangements only exist between some of the organisations represented on the project team and the close involvement of, for example, regulatory bodies and local authority departments is not based on a standard contractual arrangement.

2.10.2 Definition of project - summary

A definition of 'project' for this research needs to reflect the temporary and dynamic nature of the project for a group of organisations not necessarily linked by contracts, proposed as 'a temporary, formal group of organisations with a specific objective'. The use of 'organisation' to include the full range of project partners is explored and clarified in the next section.

2.10.3 Definition of organisation

The diverse nature of organisations as potential project partners is explored to substantiate the use of 'organisation' as a generic term for the businesses and firms involved at the various stages of the design and construction of housing. Specifically for this research, project partners in the early design phase of a housing development differ in size, function and ownership and take part in project-based work for a variety of motivations and expected outcomes. The starting point is an economic definition of a 'firm' and this is developed to encompass the various non-profit organisations of the housing development sector landscape.

A simple definition of a firm is 'the basic unit of organisation for productive activities' (Black et al., 2009). Neo-classical economic theory extends this definition to add an element of time, activity and process, describing a firm as an abstract 'primitive device for turning inputs into outputs' (Crew, 1975: 5). This activity is subject to the limitations of its technological knowledge, and guided by its objectives which may include profit maximisation, maximisation of value to shareholders, risk avoidance or

long-run growth. Firms operate in the context of competition in a complex mixed economy of dense patterns of interaction between themselves and 'other productive agents' (e.g. 'nationalised industries and non-profit institutions like hospitals and government agencies'), complemented by government whose role in this context is to manage the social welfare function of the economy (Crew, 1975).

Ideally, an economic definition of 'firm' as a project partner for this research would include these 'other productive agents', so the driver for the maximisation of profit or value for a firm is expanded to a more liberal definition that accommodates the role of 'other productive agents' at the specific stage of housing design and development. The definition of a non-profit organisation, as a 'productive agent' is noted as 'a legally constituted group organized for purposes other than generating profit and in which no part of the organization's income is distributed to its members, directors, or officers' (Ricketts, 2003: 383). They typically have legally constituted boards of trustees who employ staff to manage them and exist in areas such as education and health, and where charitable or philanthropic aims are being pursued. This definition includes housing associations and may be extended to include local authorities, with elected councillors and the employment of executives and staff. The central role of public services within a complex economy to provide and maintain an infrastructure as 'a stable environment for investment and economic growth' is noted (Fitzsimmons & Fitzsimmons, 2006: 3) with the observation that this is to be differentiated from the private, competitive service sector whose contribution to the economy can be measured in terms of its profit.

2.10.4 Definition of organisation - summary

This exploration thus defines 'organisation' for this research as a generic term to include businesses working to maximise their profit or value (such as the architect, engineer and contractor), a range of 'other productive agents' including the housing association client and local authority teams

as ‘non-profit organisations’, and the county council’s Highway Authority and the Homes and Communities Agency as tertiary service providers providing an enabling infrastructure for housing design and development. In terms of the research problem, the narrow view of construction projects as temporary groups of commercial businesses is extended to include all organisations in the early design and development stages, all of whom contribute to the project process. The focus of this research on the early design stage is considered next.

2.11 ‘The importance of the early phase’ (Kolltveit & Grønhaug, 2004)

There is very little literature that considers the early, pre-construction phase of housing development projects, either general or specifically in terms of regulation or innovation. Exceptionally, Kolltveit and Grønhaug (2004), in considering a large-scale, non-housing, construction project, focus on the importance of the early phase as an influence on eventual project performance, where cost and value are defined and the potential for innovation is at its highest. In addition, uncertainty is noted as a challenge during the early phase, in particular where there is a high degree of design novelty, such as required by, for example, the Code for Sustainable Homes, needing ‘an approved abstraction of the technical solution that satisfies the functional, quality and capacity requirements’ before progress can be made (Kolltveit and Grønhaug, 2004: 548). The early phase for any construction project under research needs to be clearly defined: for Kolltveit and Grønhaug’s major project, this is the ‘process and activities that lead to, and immediately follow, the decision to undertake feasibility studies and to execute the main project’ (2004: 547). As an over-arching definition, this is not directly echoed in the practical context of UK housing development, however their split into two sub-phases has relevance for this research where the ‘innovative sub-phase’ includes the client, the architect and decision-making local government as key participants. Key tasks for this phase are value analysis and formulation of project goals, continuing until the proposal has been

defined. The recognition by Kolltveit and Grønhaug of the under-researched and critical early project phase adds considerable value to this literature review.

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2.12 Projects - summary

The characteristics of construction projects for the purposes of the research, as temporary formations of discrete organisations (rather than the enduring end product), and the importance of the early phase, have been noted. A definition of project that is appropriate for the research has been defined as ‘a temporary, formal group of organisations with a specific objective’. Next, construction regulation, as the third element of the research, is explored.

2.13 Regulation

Regulation, as the third element of the literature review for the research, is considered within the framework of a definition and explored in the context of construction regulation. The Code for Sustainable Homes, as the focus of the research, is considered in detail as part of the regulatory landscape of the early stages of housing development.

2.13.1 Definition of regulation

Noting the comment that ‘Like innovation, regulation is not a simple, definable product’ (Kemp et al., 2000: iv), a definition of regulation that is relevant for the research takes a range of aspects arising from both general and construction literature into account. Several elements of regulation are noted and their relevance for the research is synthesised to propose a definition which reflects the regulatory landscape that impacts on the early design phase of new housing developments.

2.13.1.1 General definition of regulation

General definitions of regulation tend to emphasise a balance (Baldwin & Cave, 1999) or a discrepancy (Kemp et al., 2000) between private, market-based activity and public interests, where regulation acts on behalf of society to generate desirable communal outcomes. Both Baldwin & Cave and Kemp et al. quote Selznich's definition of 'a sustained and focussed control exercised by a public agency over activities that are generally regarded as desirable to society' (Selznich, 1985). These definitions reflects the broad benefits of regulation to society and can be contrasted with the UK government's definition of 'a rule with which failure to comply would result in a business coming into conflict with the law or being ineligible for continued funding' (BERR & DIUS 2008: 10) which emphasises the legal obligation of compliance with regulation.

2.13.1.2 Construction regulation

A definition for construction regulation extends the notion of social regulation to include both socio-economic (Banfill & Peacock, 2007; Winch, 2010) and technical (Gann, 2000; Winch, 2010) regulation. Socio-economic regulation defines what can be built where and is characterised as the planning system and technical regulation defines the standards for the constructed end-product (e.g. housing), enacted through Building Regulations. Both the planning system and Building Regulations regimes have an impact on the design phase for new housing.

The complex nature of regulation for construction is reflected in its volume. 'It is often said that construction is the most regulated of all industries: a point difficult to prove but reasonable to believe' (Morton & Ross 2008: 202).

Regulations are 'viewed by many designers and builders as an additional burden' (Gann et al., 1998: 280) rather than as a promoter and enabler of innovation, such that 'the cumulative impact of regulatory burdens on

home builders has reached a tipping point...our industry cannot be viewed as a sponge able to soak up every additional cost thrown at it' (Baseley, 2008). This reflects the view that the achievement of social policy objectives, such as environmental sustainability, should be the responsibility of government and not commercial business whose primary concern is to maximise profit for shareholders (Baldwin & Cave,1999: 329; Callcutt, 2007: 9).

2.13.2 Performance-based and prescriptive regulation

A key element of a consideration of regulation needs to note the emergence of performance-based regulation from the earlier prescriptive regulation, criticised as rigid in that materials and configurations on how to meet the regulatory goals were specified.

During the 1990s, the emphasis was on international convergence towards performance-based construction regulations where outcomes were specified. These had the combined effect of stimulating technological innovation at different stages in the production process of housing, including new product development and systems integration, and 'stimulated demand for high-performance emerging technologies' (as happened with energy regulation in the 1970s and 'clean technologies' in the 1990s). Performance-based building regulations considered building as a whole and allowed trade-offs between different parts to achieve regulatory objectives. They tended to stimulate systemic innovation rather than in parts and sub-systems. Compliance mechanisms gave freedom, market incentives and institutional frameworks in which to innovate. The burden of proof tended to slow down rates of diffusion. Some monitoring was costly and pre-production modelling was substituted for post-production performance testing (for example the Building Research Establishment (BRE)). The onus was on implementing firms to supply operational proof, which increased costs, and was often too expensive for individual firms (Gann, 2000; Morton & Ross, 2008).

However, the movement towards performance-based regulation tended to demonstrate that the regulatory process could stimulate the benefits of change, information sharing and cooperation between public and private sectors. In spite of this, there is a persisting view that regulation continues to act as an inhibitor of innovation and is 'viewed by many designers and builders as an additional burden' (Gann, 2000: 235) by setting performance limits for components for manufacturers and maintenance of standards for clients (Gann et al., 1998). Too much regulation hinders competitiveness and new product development (both crucial for innovation), and constrains the emergence of elements of de-regulation and free markets.

For organisations in the innovation superstructure, (local authorities, clients and government regulators) regulation, particularly technical, planning and environmental, 'provides the instruments with which product standards are maintained' (Gann, 2000: 234). A definition of regulation for the research recognises the notion of tension (which may or may not exist) generated by regulation between the innovation superstructure and infrastructure.

Having noted that the taxonomy of regulation includes both technical and socio-economic controls, in the context of new housing, technical regulation is designed to 'assure the integrity and performance of the constructed product', and socio-economic regulation essentially defines what is built where (Winch 1998: 271). Much of the regulation surrounding the design of new housing concerns the socio-economic definition, in particular the 'what', defining the appearance and features of both the homes and their surroundings. This sub-section does not appear to be addressed in the construction regulation literature, but is a key concern of housing design projects responding to a double set of regulations on planning and on building (Banfill & Peacock, 2007) and therefore justified

as a research focus, and 'regulation' for the purposes of the research includes that which Winch would define as 'what and where'.

A facet of regulation that is relevant for a definition for the research is noted by Kemp et al (2000: iv). They recognise that there is a difference between 'what is required by law and the real conditions of compliance' which can be negotiated with the agency who implements the regulation within the agency's regulatory style which may be, for example, confrontational or collaborative. Negotiation, and specifically negotiation around innovation to meet regulatory requirements (as noted by Winch, 1998: 273) is found to be an important element of the case study context in responding to regulation with innovative solutions.

2.13.3 Definition of regulation - summary

Thus, a definition of regulation is proposed from the elements noted above as 'the negotiated application by the innovation superstructure of socio-economic and technical requirements that deliver the social goals of new housing'. For the research, regulation is used as a generic term to include the obligatory requirements generated by other organisations within the given environment.

2.14 Housing construction and regulation

All the phases of housing construction, (design, build, occupation and eventual decommissioning) are carried out within the prevailing regulations and specifications (Slaughter, 1998) of the current social and political context, of which the case study for the research is an example. The requirement to meet the Code for Sustainable Homes in the context of both recent, long-established and revised regulations for each of the project organisations reflects national, regional and locally-enacted legislation, standards, codes and good practice guides and manuals, and these are considered in detail as part of the data analysis section. The

Code for Sustainable Homes, as the focus for the research, is introduced here.

2.14.1 The Code for Sustainable Homes

The Code for Sustainable Homes (the Code) (DCLG, 2008a) acts as the focus for the research, as a regulation that compels the housing construction project sector to innovate to meet sustainability measures within a specific timescale. This section considers the Code in detail, noting its provenance and context, describing its sustainability measures and assessment mechanisms and examining its references to and implications for innovation. The wording of the Code has been revised since its publication in 2008, and the accompanying Technical Guidance adjusted to incorporate alignment with Building Regulations. The case study for the research was carried out under the 2008 edition and this is reflected in the literature review. First, 'sustainability' as a concept for development is explored.

At a global level a definition for 'sustainable development' proposed by the influential World Commission on Environment and Development's (WCED) report, commonly known as the Brundtland report after the United Nations commission's leader, Gro Harlem Brundtland, has been generally accepted as 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs' (WCED 1987: 43). This definition is open to debate, where 'development' can be quantitative or qualitative, relating to economic models or to concepts of social justice or stability, and 'need' can range from basic needs through to individual or social wants and desires. The definition also assumes that the needs of future generations can be predicted. Within this, the notion of 'sustainable' as an adjective for housing (or any other area, for example energy, transport, communities or resources) is ambiguous (Pickvance & Chotard, 2006).

Echoing this potential for ambiguity, sustainability in the Code for Sustainable Homes is variously identified, though not explicitly defined, as a minimisation of CO_2 emissions, as a reduction of other environmental impacts of housing construction and as an improvement of overall well-being and quality of life.

2.14.1.2 The Code for Sustainable Homes - provenance

The immediate regulatory forerunner of the Code was the EcoHomes standard developed by the Building Research Establishment (BRE) in 2000 as a method for assessing environmental impact of new housing, applicable to developments in receipt of social housing grant administered by the Homes and Communities Agency. Table 2.4 lists and summarises the significant policy antecedents of the Code in chronological order (based on tracking references through documents) showing that it emerged from a series of drivers that reflected concurrent and increasing social and political concerns on environmental sustainability and on the role of housing within these concerns.

Table 2.4 Provenance of Code for Sustainable Homes

Date	Document	Dept.	Detail
May 1999	A better quality of life: strategy for sustainable development for the UK	HM govt.	Outlined four aims for sustainable development: social progress which recognises the needs of everyone; effective protection of the environment; prudent use of natural resources; and maintenance of high and stable levels of economic growth and employment.
2000	EcoHomes	BRE	Environmental rating scheme for new and refurbished homes administered by BRE. Mandatory for social housing from 2003 and 200,000 homes have been certified since 2000. It was replaced by the Code in England, Wales & NI in April 2007.
Apr. 2000	Building a better quality of life: a strategy for more sustainable construction	DETR	Defines a framework for a more socially and environmentally responsible, and better regarded construction industry that can contribute to the better quality of life outlined in the sustainable development strategy of May 1999 (above).
Apr. 2000	Quality and choice: a decent home for all	DETR green paper	Comprehensive cross-tenure review, as a basis for housing strategy.
Feb. 2003	Our energy future: creating	DTI white	Summarises the govt.'s intention to put a low carbon economy at the heart of its energy

	a low-carbon economy	paper	strategy, and sets out a long term goal of reducing CO_2 emissions by 60% by 2050, with 'real progress' to be shown by 2020. [5]
Feb. 2004	Delivering stability: securing our future housing needs	HM Treasury and ODPM indepen-dent review	'The Barker Review'. Kate Barker's influential review of the function of the housing market, recommending an increase in new homes of 70,000 p.a. to deliver a lower trend in house prices to improve affordability and steady market volatility.
Mar. 2005	Securing the future: UK government sustainable development strategy	HM govt.	Update of May 1999 strategy, including a new integrated vision with stronger international and societal dimensions, a more explicit focus on environmental limits; and priorities of sustainable consumption and production, climate change, natural resource protection and sustainable communities.
Oct. 2006	The economics of climate change	HM Treasury indepen-dent review	'The Stern Review' on the economic imperative to reduce CO_2 emissions.
May 2007	Meeting the energy challenge	DTI white paper	International and domestic energy strategy to reduce CO_2 by 60% by 2050, maintain reliable energy supplies, promote competitive energy markets and adequately and affordably heat all homes.
Jul. 2007	Homes for the future: more affordable, more sustainable	DCLG green paper	Looked for views on proposals to increase the supply of housing, to provide well designed and greener homes that are supported by infrastructure and to provide more affordable homes to buy or rent.
Jul. 2007	Building a greener future	DCLG policy statement	Confirms the Government's intention for all new homes to be zero carbon by 2016 with a major progressive tightening of the energy efficiency Building Regulations - by 25% from 2010 and by 44% from 2013 - up to the zero carbon target in 2016.

The ambitious and increasing CO_2 reduction target from 60% to 80% for the UK which acts as a driver for sustainability in housing is embedded in a series of commitments summarised in Table 2.5.

[5] The UK Climate Change Act 2008 increased the reduction target to 80%.

Table 2.5 UK CO_2 reduction framework (adapted from SCRI, 2010)

Commitment	% reduction target	Date
1990 Kyoto Agreement	12.5%	2012
EU 20:20:20 Directive	20%	2020
UK Climate Change Act 2008	80%	2050

The policy and associated formal government documentation indicate a growing and strengthening reflection on the complex relationship of more, better and cheaper housing, as expressed in 'Homes for the future: more affordable, more sustainable' (DCLG, 2007a) which contributes to the housing targets of the Barker review, the sustainability of housing supply and the role of housing in broader economic prosperity.

The relationship of Part L Building Regulations to the Code is relevant. Future revisions to Building Regulations, pegged at three-yearly intervals for 2010, 2013 and 2016, will link the Code's percentage reductions of CO_2 emissions to 2006's Part L. Consultation began on Part L's 2013 revision in 2009, so that as the 2010 revision becomes operational, changes from 2013 will already be known.

It should be noted that a proposal for the introduction of the Code was the subject of a DCLG consultation paper in December 2005, with the intention of developing a voluntary system of sustainable housing construction standards. The consultation exercise generated 444 responses, of which 'Commercial developer', 'House or property developer' and 'Builder / other contractor' together accounted for less than 3% (13 in number) of responses. This is significant in that 'house builders and developers will play a major part in delivering the sustainability objectives of the Code' (DCLG, 2006: 7). Generally, respondents to the consultation indicated a preference for avoiding regulation to promote greater sustainability, but hoped for wide voluntary compliance.

2.14.1.3 The Code for Sustainable Homes - details

The Code is 'an environmental assessment method for rating and certifying the performance of new homes. It is a voluntary national standard for use in the design and construction of new homes with a view to encouraging continuous improvement in sustainable home building' (DCLG, 2008a:7), operational from April 2007. Social housing in receipt of NAHP funding from the HCA is required to meet a mandatory minimum Code level 3 from April 2008. Assessment for private housing is voluntary (although from 2010 there was a mandatory minimum of Code level 3, incorporating a CO_2 reduction target of 25% in line with revised Building Regulations).

The Code sets out a series of nine criteria against which credit points are generated, with a series of thresholds which delivers an overall sustainability rating, denoted by a set of stars. The minimum one star reflects the entry level, indicating performance above the minimum level defined by Building Regulations, and the maximum six stars, as 'an extremely challenging standard' (DCLG, 2008a: 10) reflects the highest sustainability criteria that can be achieved within the Code. The star rating is presented on a certificate as part of the formal paperwork for the purchase of new private homes, or for the transfer to social housing clients. New homes that are not assessed against the non-mandatory criteria are given a zero-star rating certificate.

Compliance with the Code is assessed by BRE trained and accredited assessors and includes an initial design stage assessment based on detailed documentary evidence and commitments, usually after planning permission has been granted, which results in an interim certificate of compliance with a recommended sustainability rating recorded on an interim compliance certificate. The final assessment is carried out after construction and includes a confirmation of compliance, including site records and visual inspection, leading to a star-rated certificate. Data on

certificates issued at each stage at Code level is collated and presented quarterly by the DCLG.

Of the nine criteria, the Code includes two with increasing minimum mandatory standards, discussed below.

The mandatory criteria for Energy and CO_2 emissions (Ene1) are reflected in Building Regulations which are embedded in a legal framework and therefore compulsory. This includes a timetable for achieving stepped reductions in CO_2 emissions (based on measured Dwelling Emission Rates (DER) above Target Emission Rates (TER)), noted in Table 2.6.

Table 2.6 CO_2 reduction (from 2006 Building Regulations Part L - 100%)

Year	Reduction	Code level
2010	25%	3
2013	44%	4
2016	100%	5
2016	'zero carbon'	6

A five star rating reflects a 100% reduction from 2006 Part L, with no emissions from heating, hot water, ventilation and lighting, compared to a six star rating, achieved when a home is measured as 'zero carbon', with 'zero net emissions of CO_2 from all energy use in the home' (DCLG, 2008a: 7). Level 6 does not include any CO_2 generated in the design and manufacture of the home or its components, or in any 'carbon footprint' associated with residents living in a neighbourhood and using the local infrastructure. It refers to the technologies in place to achieve zero carbon for new homes but does not extend to either the building process or the behaviours of occupants, both of which may compromise the 'zero carbon' emission. The definition of zero carbon has been under discussion for several years by the government and associated bodies representing both the construction sector and the sustainability lobbies and organisations.

Indoor water use (Wat1) sets reducing amounts of maximum potable water consumption per person per day, from 120 litres for Codes 1 and 2, down to 80 litres at Code levels 5 and 6.

A further four criteria require a single mandatory performance across all Code levels. Additional credits are available across a range of further criteria, and subjected to a weighting exercise to arrive at a star rating. Weighting factors emerged from BRE studies with industry and international experts, taking account of the contribution of new UK housing on environmental impact, and the potential for mitigation of these at both design and construction stages. Table 2.7 (adapted from DCLG, 2008a, Tables 1, 4 and 5: 10 - 15) captures the detail of the Code at the time of the case study on Project A, noting the nine criteria, their credits, weightings and mandatory status.

Table 2.7 The Code for Sustainable Homes - criteria, credits and weighting

		Credits	Weight factor %	Weighted value
Energy and CO_2 emissions				
*M 1	Dwelling Emission Rate	15		
2	Building fabric	2		
3	Internal lighting	2		
4	Drying space	1		
5	Energy labelled white goods	2		
6	External lighting	2		
7	Low or zero carbon technologies	2		
8	Cycle storage	2		
9	Home office	1		
Total		**29**	36.4	1.26
Water				
*M 1	Indoor water use	5		
2	External water use	1		
Total		**6**	9.0	1.50
Materials				
M 1	Environmental impact of materials	15		
2	Responsible sourcing – building elements	6		
3	Responsible sourcing – finishing elements	3		
Total		**24**	7.2	0.20
Surface water run-off				
M 1	Management of surface water run-off	2		
2	Flood risk	2		
Total		**4**	2.2	0.55
Waste				
M 1	Storage of non-recyclable & recyclable waste	4		
M 2	Construction waste management	3		
3	Composting	1		
Total		**7**	6.4	0.91
Pollution				
1	Global Warming Potential	1		
2	NOx emissions	3		
Total		**4**	2.8	0.70
Health and wellbeing				
1	Daylighting	3		
2	Sound insulation	4		
3	Private space	1		
M 4	Lifetime Homes	4		
Total		**12**	14.0	1.17
Management				
1	Home User Guide	3		
2	Considerate constructors scheme	2		
3	Construction site impacts	2		
4	Security	2		
Total		**9**	10.0	1.11
Ecology				
1	Ecological site value	1		
2	Ecological enhancement	1		
3	Ecological protection	1		
4	Change in ecological value	4		
5	Building footprint	2		
Total		**9**	12.0	1.33
TOTALS		104	100%	-

Assessments are calculated in three stages. First, the mandatory, non-creditable, issues are checked (marked M in Table 2.7). The mandatory credits for CO_2 emissions and internal water use are confirmed at the minimum needed to meet the Code level sought, then the remaining credits are counted and weighted to give a score and associated star rating. Figure 2.6 reflects this process.

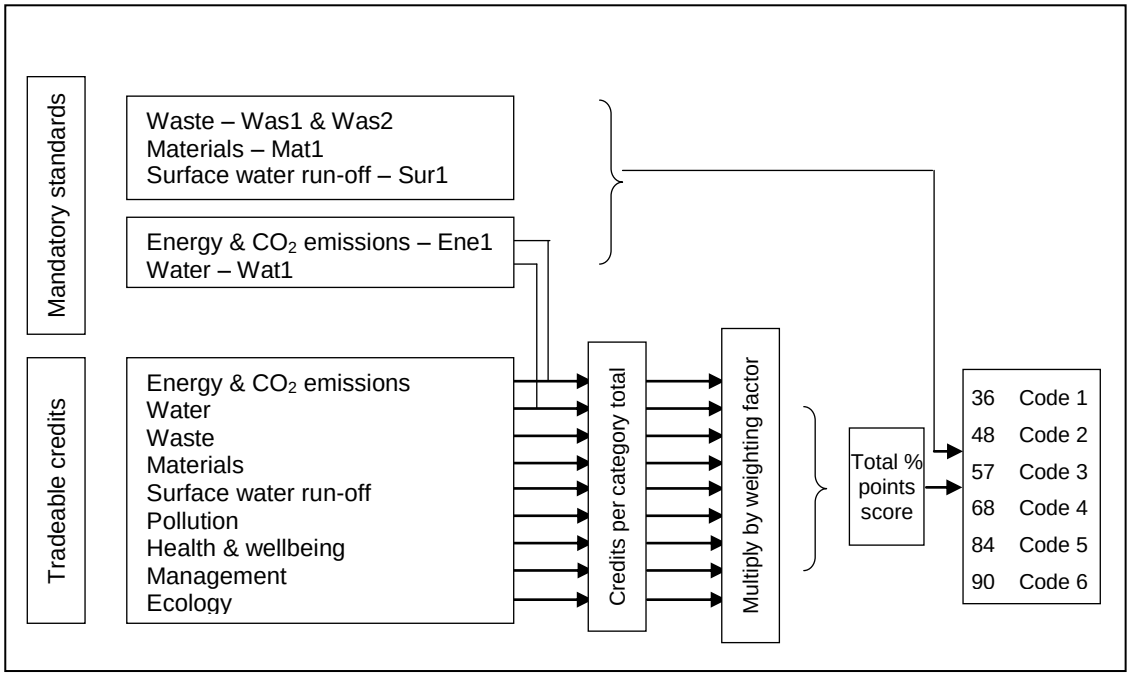


Figure 2.6 Calculating a Code score (adapted from DCLG 2008a: 18)

2.14.1.4 The Code for Sustainable Homes - responses

The Technical Guidance that accompanies the Code (DCLG, 2008b) is based on measures of performance that demand innovative solutions to ensure compliance. The challenge is for government policy and the house-building sector to work towards appropriate innovation that both meets the regulations within the Code and, at the same time, enables firms to sustain competitive advantage and organisations working together at project level to do so effectively and efficiently. The apparent tension between these aims is expressed in terms of cost and responsibility (Callcutt, 2007).

Achieving various Code levels through generating points to reach thresholds represents a flexible performance-based regulation which has the capacity to encourage innovation, as noted in Section 2.13.2. The 'radical changes to construction methods and practices' and the 'evolution of a new architectural vernacular' implied by the Code (Banfill & Peacock, 2007: 434) imply innovation beyond the low level innovation associated with housing construction, as noted in Section 2.8.2.

Although the aspirations of the Code are considered to be both 'admirable' (Banfill & Peacock, 2007: 434) and 'ambitious' (Osmani & O'Reilly, 2009: 1917), the cost of meeting these falls upon the housing construction sector, already heavily regulated, as noted in Section 2.13.1.2. The cost of building a Code 4 home is assessed as 6% to 8% above base-build cost, 25% to 30% for a Code 5 home and 30% to 40% for Code 6 (DCLG, 2008b: 10). The business benefits of meeting the Code are described by the government as an opportunity for housebuilders to 'demonstrate sustainability performance and differentiate themselves from competitors' (DCLG, 2008a: 6) as a mark of quality. However, innovation and the benefits arising from it, are not specifically referred to in the text of the Code.

Banfill and Peacock (2007) and Williams and Dair (2007) identify a strong policy drive for achieving sustainable building, within which the construction sector is reluctant, given the risks associated particularly with the concept of micro-generation technologies, to achieve higher Code levels. The technologies exist to provide lower CO_2-emitting space and water heating (Banfill & Peacock, 2007; Osmani & O'Reilly, 2009, DCLG, 2008b; Callcutt, 2007) and the requirement is to achieve the use of these technologies as a 'universal practice' (Banfill & Peacock, 2007: 434). The technologies for meeting zero net CO_2 are less well-developed and imply significant changes not only for housing construction but also, for example in associated industries such as electricity generation and supply. The

risks and costs involved for early adopters of micro-generation technologies are commercially uncertain and the benefits are unknown.

The Code notes that a 'more environmentally-conscious public' (DCLG, 2008a:6) will generate demand for new sustainable homes with reduced running costs and lower environmental impact. A 2008 study found that the requirements of the Code to reduce CO_2 emissions were seen as desirable by 80% of homeowners, and as realistic by 33%. (NHBC Foundation, 2008). 'The key driver of ... investment in energy efficiency and CO_2 reduction is return on investment' (NHBC Foundation, 2008:11) and the study found, based on a reducing return from costs provided by government and not including any housebuilders' margin, that the lower the return compared to additional cost, the more likely potential new home buyers would be to buy a Code-assessed home. Homeowners would prefer a traditional appearance, and features discouraging purchase would include lack of gas appliances, 'power showers' and opening windows. This last feature is the one most resisted by potential purchasers, due to unfamiliarity of the concepts of 'air tightness' and artificial ventilation. Generally, housing consumers prefer traditional homes (as noted in Section 2.8.2) and that the 'changes in cultural literacy' (Banfill & Peacock, 2007: 435) needed to normalise housing that requires a different style of occupation will not happen quickly enough to pay back the costs associated with their development.

2.14.2 The Code for Sustainable Homes - summary

The impact of the Code, as a major recent performance-based regulation, has implications for the way that housing is designed that needs to be absorbed within the range of existing design standards. The research illuminates part of this landscape by focussing on the design of social housing to meet Code level 4, and two Research Questions are proposed to support this focus in the next section.

2.15 Synthesis of the research elements of innovation, projects and regulation

Having reviewed literature on the three separate elements of innovation, projects and regulation, the three 'element pairs' are considered; innovation and regulation, innovation and projects, regulation and projects; before being synthesised to substantiate the research and inform two Research Questions.

2.15.1 Innovation and regulation

Gann notes that 'our understanding of innovation in construction processes is far from complete' (Gann, 2000: 210) and list five elements that require further attention, including the regulatory environment in which innovation takes place, which is illuminated by this research. Winch (1998) notes the connections between innovation and regulation in project-based working from the perspective of project-based firms, and Gann (2000) notes the need for project-based firms to assimilate project-generated innovation into 'organisational memory'.

In developing this argument, Gann (2003) contributes a useful point to the research justification, noting that regulation does not necessarily drive innovation in ways of working because project management is not normally subject to regulatory conditions. However, innovation in ways of working may act as a lever for accelerating innovation in products and processes to meet criteria for performance-based regulation of, for example, the Code for Sustainable Homes. Further, 'economies of effort' may deliver more purposeful ways of improving performance in project working, which challenge more traditional practices. Thus the research area is both subtle and nuanced.

These points are usefully amplified and summarised by Shields (2005: 19) who notes that construction innovation research has a tendency to focus on the 'on-site activity' rather than on the associated framework, that the

focus has been on firms rather than projects because both economic theory and policy-making locate innovation and its value in the context of firms, and that construction research continues to view innovation as primarily associated with firms' products, rather than as a process within a broader complex system.

Within this context, this research considers innovation in response to regulation at the inception, planning and design stage of the project itself for all the organisations involved for which innovation, and its value, has different meanings at their own sector levels and at an individual organisation level.

2.15.2 Innovation and projects

'A dearth of research' on innovation in project-based firms has been identified (Keegan & Turner, 2002: 367), where innovation in 'project-based, service-enhanced enterprise' is not 'adequately addressed' (Gann & Salter, 2000: 955). However, although a recent growth in the focus of research in project-based innovation has been noted (Acha et al., 2005) this is still primarily at the level of firms participating in projects, rather than in the context of the complex interplay of organisations in the project itself. In addition, Harty notes that current thinking on innovation in construction 'fails to take multiple and contrasting perspectives' (Harty, 2008: 1029) into account, recognising that the range of organisations involved in projects will have different, and potentially conflicting, perspectives and drivers.

The inherent nature of projects as temporary groups of organisations tends to inhibit innovation within projects (Gann, 2000; Sexton & Barrett, 2005) and establishing the ownership and associated benefits arising from project-based innovation in products and processes is difficult to establish (Barlow, 1999; already noted as a potential reason for housing construction as a low-level innovation).

Gann notes that project-based construction firms are good at project work but often less good at 'organising internal business processes' (Gann, 2000: 226) because projects are one-off and task-oriented, where every project is regarded as new and there is little transfer of knowledge from projects to the 'internal structure, systems & cultural attributes' (Gann, 2001: 327) to be used as a starting point for future projects. This contributes to the view that the sector has both too much and too little innovation - 'there are plenty of new ideas, but they tend not to achieve good currency' (Winch, 1998: 271) thus not fulfilling the definition of innovation as the successful application of a new idea (as defined in Section 2.3). The 'good currency' needs to be applied to subsequent projects to generate value in order for new ways of project working to be successful.

Further, Lu and Sexton (2006) note the differences between 'explorative innovation' for solving problems presented at individual project level, and the 'exploitative innovation' arising from this that can add organisational value, or reduce the cost of time, and bridging the gap between the two innovation types is identified as the challenge for construction projects (Gann, 2000; Dubois & Gadde, 2002). This would move housing construction innovation from the product-based 'low level innovation' discussed in Section 2.8.1 to the assimilation of the value of process-innovation to an organisational level defined as 'organisational memory', adapting knowledge gained from problem-solving in specific projects as 'algorithms of repeated activity' (Nelson & Winter, 1982, noted by Acha et al., 2005).

Thus the literature shows that project-working tends to inhibit innovation, and that the value of any explorative product or process innovation that arises is difficult to assign to any project organisation as exploitative. This research aims to include an identification and assessment of innovation in the context of an early-phase SOCIAL housing development project.

2.15.3 Regulation and projects

There is minimal literature that focuses on the links between regulation and projects, although Gann (2000) notes that a project-based environment generates a dynamic process for organisations within both a shared and discrete regulatory landscape. This dynamic process, within the regulatory given environment, can promote or inhibit innovation. The research aims to add value to the landscape of innovation, regulation and projects by specifically considering this landscape and the associated innovation responses.

2.16 Research questions

Having defined the three key terms of the research and considered and synthesised themes from the relevant literature, two research questions are articulated as follows:

Research Question One: What is the impact of the Code for Sustainable Homes on the early stages of social housing development projects?

Research Question Two: How do social housing development projects innovate to meet the Code for Sustainable Homes?

The two Research Questions are given a contextual framework by Sexton and Barrett's (2003) model of the factors of innovation. This model is generated from research which identified the four organisational antecedents of innovation, however, the value for the two Research Questions is located in the surrounding given and interaction environments within which innovation takes place. The given environment is defined as 'the business environment that firms are influenced by, but which they cannot influence themselves', and the interaction environment is defined as 'the business environment that firms can interact with and influence' (Sexton & Barrett, 2003: 627). This framework and its associated definitions add purpose and clarity to the research questions,

where Research Question One is reflected in the position of regulation as part of the external environment and Research Question Two is expressed as innovation within the interaction environment. Figure 2.7 reflects the framework.

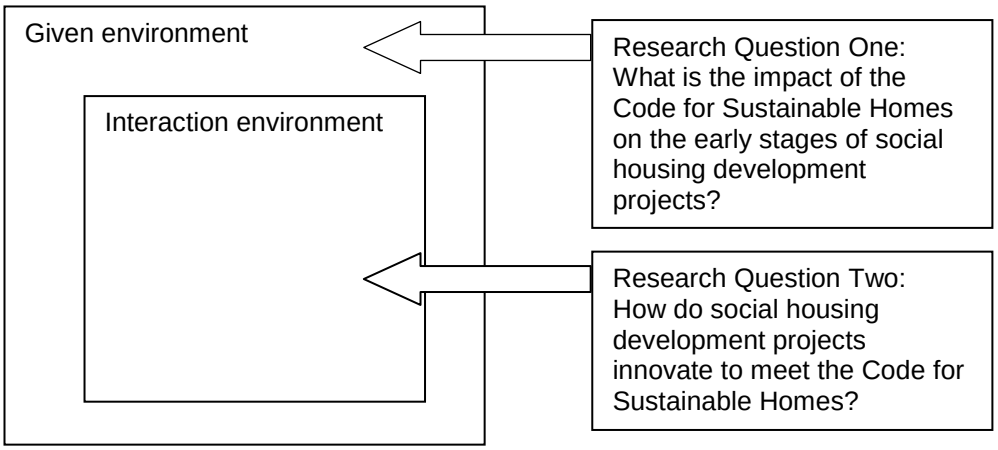


Figure 2.7 Framework for Research Questions (Sexton & Barrett, 2003)

2.17 Synthesis of literature review - summary

The research is justified and contextualised with reference to relevant literature on innovation in projects, and on the impact of regulation on construction innovation, though no direct research that specifically links all three elements of innovation, regulation and projects in construction has been found. New knowledge is created from the exploration of the tri-partite relationship of regulation-driven innovation in the early design stage of housing development projects.

For the purposes of the research, innovation has been defined as 'the process of the successful application of a new idea that adds value'. A project is defined as 'a temporary, formal group of organisations with a specific objective'. Regulation is defined as 'the negotiated application by the innovation superstructure of socio-economic and technical requirements that deliver the social goals of new housing' and is used as a

generic term to capture the full range of requirements, standards, legislation and regulation in the given environment within which organisations and projects need to work.

The stance taken for the research is that the housing development project sector, in extending its capacity for innovation to meet the requirements of the Code for Sustainable Homes within a framework of existing regulation, needs to innovate beyond the 'steady state' of organisation-level incremental innovation in product and process and start to engage with and successfully manage innovation at the higher levels within a CoPS context. The two Research Questions have been articulated to focus on regulation and on innovation as dependent elements within a project context.

Finally, Winch (1998) notes that a case study approach to enable theory building to extend the knowledge of innovation processes is appropriate, and this recommendation is explored and justified in Chapter Three.

**The Code for Sustainable Homes:
what are the innovation implications
for the social housing development sector?**

Chapter Three: Methodology

3.1 Introduction

Having defined the Research Questions arising from the literature review informed by the research problem, the methodology for addressing the questions is developed in Chapter Three. This is achieved by following a process linking philosophy, approach and technique, and concludes with the design of a case study. The Chapter starts with a note on the nature of research and the importance of sound methodologies.

Research is defined as 'any form of disciplined enquiry that aims to contribute to a body of knowledge of theory' (ESRC, 2007: 7) and for this contribution to be effective, the research needs two defining characteristics. First, it should be carried out within an explicit philosophical framework and secondly, it should adopt and justify an appropriate methodological approach. The researcher should be familiar with the philosophical background and framework, locate the research methodology within it and be able to discuss and defend this position with confidence and clarity. This familiarity 'enables the researcher to take a more informed decision about research design... to understand which design will work and, crucially, those that will not [and] to adapt different research designs according to the constraints of different knowledge structures' (Easterby-Smith et al., 2008: 56).

Research methodology is defined as the science of the logic, methods and techniques of scientific enquiry which structures and guides a research strategy to make it meaningful (Grix, 2004). It expresses the elements of research as a coherent whole, linking and justifying the strategies for answering the research questions within a philosophical framework. By forming a robust research methodology, a researcher can define a problem articulated by a set of well-defined questions and develop an appropriate approach within a framework that recognises and responds to a coherent research philosophy and generates results that are valid and reliable.

3.2 Research methodology

Research into construction is a relatively recent academic discipline and needs to develop similar rigour and objectivity to other, more established fields, by applying sound methodologies and systematic, thorough execution (Fellows & Liu, 2008). As 'construction management is essentially a social phenomenon' (Love et al., 2002: 295) and the projects that form the 'modus operandi' of the sector are dynamic and complex, consisting of multiple interdependent components, interacting feedback processes and non-linear relationships, construction management research is characterised as a social science (Dainty, 2008: 1). There are two potential approaches for social science research, one rooted in the systematic, positivist approach of the natural sciences and the alternative based on a qualitative account of events. This qualitative approach can be justified as a research methodology on the condition that any bias generated by the researcher or the subjects is both recognised and controlled (Kumar, 2005). The challenge for qualitative research, within a dominant philosophical tradition that continues to value a positivist approach, is to replicate the objectivity of the natural sciences by recognising and mitigating against the effects of human beliefs and opinions of both the researcher and the participants, at the same time as recognising the inherent value of qualitative research and the valid contribution it makes to knowledge (Fellows & Liu, 2008; Kumar, 2005). Although Love et al., (2002) argue that the use of the methodologies and tools of natural science for construction management research is flawed because of the human element of construction, the objectivity and reliability that these methods generate for problems that can be both complex and messy is attractive.

The academic community has produced various general and subject-specific texts (e.g. Denscombe, 2003; Robson, 2002; Fellows & Liu, 2008; Knight & Ruddock, 2008) and devised models such as the 'research onion' (Saunders et al., 2007) and a four-stage linked approach (Crotty, 2003: 4)

to guide researchers in the formation of appropriate methodologies for their research. These variously seek to capture and summarise the relevant philosophical concepts and to link these to research approaches and techniques. In addition, industries and government sectors publish their own guidelines and requirements for research, for example the Science and Engineering Research Council (SERC) construction management research programme process, noted by Fellows and Liu (2008: 53). The researcher is thus provided with an extensive range of information, advice and examples and must select and justify a specific approach from the options available.

This research adopts the 'nested' approach (Sexton, 2004) as the preferred model for directing the development of a sound methodology. This simple and effective device anchors the core of the research - the techniques for generating data that are compatible with the appropriate approach for addressing the research question - within a framework that defines the philosophy, giving clarity and purpose to the approach and techniques of the research process. Figure 3.1 illustrates this approach and the three nested elements are discussed below. It should be noted that this model uses 'approach' as an alternative to 'method' to avoid confusion with 'methodology' as an overall framework for research (Sexton, 2004) and this terminology is applied in the development of the methodology for this research.

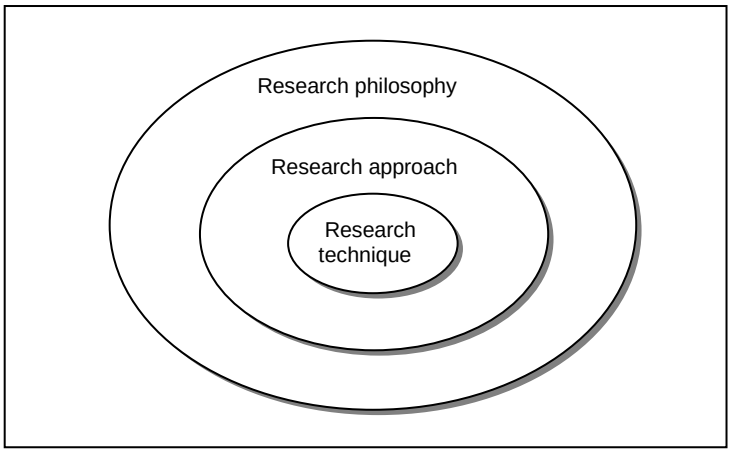


Figure 3.1 Nested methodology (Sexton, 2004)

3.3 Research methodology - philosophy ('the love of wisdom')

The nature and history of philosophy ('the love of wisdom' from the Greek 'φιλοσοφία'; 'φιλεῖν' (to love) and 'σοφία' (wisdom)), are briefly explored through the three fundamental concepts of ontology, epistemology and axiology to articulate some of the rich philosophical history and context within which this particular early 21st century research problem and the appropriate approach and techniques for addressing it are located. Ontology concerns the nature of reality, epistemology considers how we know about reality, and axiology recognises the implicit values of the researcher in finding out about reality.

The following paragraphs show that three concepts of ontology, epistemology and axiology encompass a range of positions and it is helpful to express these as points on a series of lines (e.g. Collins, 1998) as in Figure 3.2. This guards, to some extent, against the tendency to polarise, where 'qualitative research and quantitative research are set against each-other as polar opposites' (Crotty 2003: 15), 'in the red corner is constructionism; in the blue corner is positivism' (Easterby-Smith et al., 2008: 57). Crotty (2003) emphasises the links rather than the divisions of philosophical positions, and thus the use of continua signified by shaded arrows in subsequent figures and tables demonstrates this balance, supported by a non-adversarial vocabulary.

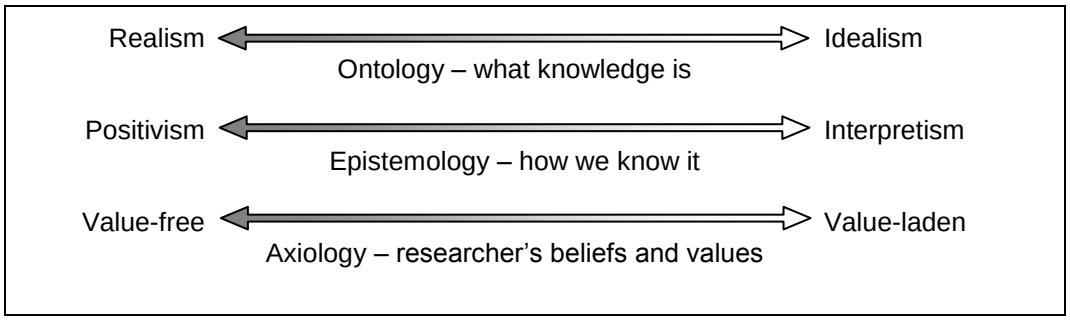


Figure 3.2 The continua of three key philosophical concepts (adapted from Sexton, 2004)

An understanding of these concepts informs an appreciation of the body of knowledge that the research findings aim to extend, and this understanding begins with a consideration of the relationship between philosophy and knowledge.

3.3.1 Philosophy and knowledge

There are two major research models that inform research methodologies and these have an extensive, complex and well-documented history. An account of knowledge in Europe can be broadly defined as the long development and establishment of a positivist tradition, balanced with the more recent emergence of an equally valid constructionist model, and recent history of knowledge includes an account of the growing co-existence of these two ways of knowing the world, providing a mature and balanced way of validating research methodologies that aim to increase our knowledge.

The sum, or body, of knowledge evolves and extends over time with the addition of new research findings. This places new knowledge, and the understanding and use of existing knowledge within the circumstances of the time, reflecting and responding to concurrent research interests within the context of current social, political and cultural circumstances (Turnbull & Knight, 2008). Additionally, research carried out will take place within the constraints of concurrent history and conventions (Knox, 2003).

Positivism, as 'the march of science' (Crotty, 2003: 18) provided the reassurance of an unambiguous and accurate knowledge of the world during the Renaissance and the Age of Reason (spanning the 14th to 18th centuries in Europe) during, and in the context of, an era of unprecedented historical change, including the growth of a secular knowledge of the world based on empirical, observable data, which displaced the predominant religious, belief-based, understanding. The current meaning of positivism is still closely aligned to the principles of natural science and the resultant knowledge is held to be accurate and certain, although Crotty (2003) notes that both its critics and 'insiders' now recognise probabilities rather than certainties, and that its claims to absolute objectivity are aspirational.

The emergence of constructionism[6] - 'the making of meaning' (Crotty, 2003: 42) - as a way of understanding reality provides a balance to positivism. Constructionism holds that meanings are constructed by people as they engage with the world they are interpreting (Crotty: 2003: 42), so that consciousness of external objects assigns meaning, rather than the existence of the objects themselves. This significant alternative to positivism can be identified as the growth of the sociology of knowledge, with early elements traced back to the 19th century work of, for example Hegel and Marx (Crotty, 2003) and developed during the 20th century, particularly in America with the influential work of Berger and Luckmann (The Social Construction of Reality, 1967). Their argument, that knowledge is derived from and maintained by social interaction (Flick, 2006) was shown to be relevant for research across a range of academic and practical disciplines.

Having briefly described the two contrasting accounts of a traditional, scientific view of reality as external and governed by natural laws, and of a

[6] There is a difference between constructionism as a socially shared reality - 'the collective generation of meaning' and constructivism as a unique individual experience - 'the meaning-making activity of the individual mind' (Crotty, 2003: 58). Because this research considers a shared project environment, constructionism is preferred.

social reality, knowable through a shared understanding, these can now be extended within specific considerations of ontology, epistemology and axiology, within which the two contrasting positions continue to be relevant. This discussion informs the philosophical context of the research and is used to define an appropriate research approach and technique within the 'nested philosophy' model at Figure 3.1.

3.3.2 Ontology

First, ontology, from the Greek 'οντο' (to be) describes the nature of reality (Collins, 2000; Grix, 2004). Positions on its spectrum range from realism to idealism, where realism expresses the objective reality of objects and events (Fellows & Liu 2008), independent of our awareness or consciousness of them (Crotty, 2003). At the other end of the spectrum, idealism describes a reality that is perceived in different ways by individuals (Sexton, 2002) where everyone experiences a discrete, subjective reality of objects and events.

3.3.3 Epistemology

Epistemology, from the Greek 'ἐπιστήμη' (knowledge) concerns the origin, nature, scope and limits of knowledge (Crotty, 2003; Grix, 2004; Fellows & Liu, 2008) and is generally expressed in philosophical terms of positivism (as discussed above in Section 3.3.1) and interpretism[7]. Epistemologically, positivism aims to establish the general laws of, and cause-effect relationships that exist between, events by using systematic, rational methods. Alternatively, interpretism aims to explain human actions by understanding how the world and its events are perceived by the individuals who experience them, where 'meaning is not discovered but constructed' (Crotty 2003: 9).

[7] The research follows a preference for the use of the Australasian spelling of 'interpretism' as the noun and 'interpretist' as the adjective, rather than the longer 'interpretivism' and 'interpretivist' (Raftery et al., 1997).

3.3.4 Axiology

Axiology, from Greek ‘ἀξίᾱ’ (value or worth), is the study of values. This contributes to the development of research methodology because it describes the position and role of the researcher who brings implicit values, beliefs and experience to the research, particularly for approaches that are aligned with an interpretist epistemology. Value-neutral research aims to be objective and value-free, as a contrast to value-biased research where the design of a research approach should explicitly recognise, account for and mitigates against the potential effects of subjectivity or bias (Sexton, 2002; Easterby-Smith et al., 2002).

3.4 Philosophical position of the research

There has been lively academic debate amongst construction management researchers into the best or most appropriate methodologies for solving the problems and unearthing new knowledge for construction management with, for example, Seymour et al., (1997) recommending an interpretist approach, Runeson (1997: 299) backing positivist approaches as an ‘insurance against bad research’ by reducing subjectivity within an established and disciplined paradigm and Raftery et al., (1997) supporting the benefits of a multi-paradigm approach which includes the use of a rationalist stance to understand the ‘cause and effect’ of the actions and perceptions of construction management participants.

The recognition of a hybrid, multi-paradigm approach is emerging for construction management research that includes both natural and social science traditions (e.g. Love et al., 2002; Dainty, 2008). Knox (2003) noted by Pathirage et al. (2008) argues that the alignment of research approaches to one of the two philosophies, implying a mutual exclusivity, is both non-rational and limits and confuses the research process. The two positions can be reconciled by the practical nature of research, involving a compromise between related concepts offering a set of inductive and deductive tools (Remenyi et al., 1998 noted by Easterby-Smith et al.,

2002: 57) whose use is ‘advantageous’ (Saunders et al., 2007: 119). Knox (2003) discusses the ‘elective affinity’ (2003: 124) that exists between research philosophy and approach, where an ontological view will suggest an appropriate approach, and from this position the range of research tools and techniques is available within a properly constructed research methodology (Knox, 2000; Pathirage et al., 2008).

A methodology for research into the Code for Sustainable Homes as a regulation, and the innovation required by design project teams to address it, needs to recognise and accommodate the position that both are products of a shared, socially constructed reality and that the organisations working within the housing development sector are an intrinsic part of this reality. This places the research problem towards the contructionist end of the philosophical continua of Figure 3.1 as a subject for study.

3.5 Research philosophy - summary

The two key philosophical positions have been outlined and considered in relation to the research problem. The shared perspectives of the case study participants with a range of professional and personal capacities, skills and constraints in the project context of the design of new social housing to meet the Code for Sustainable Homes, constitute a socially interpreted reality. This justifies a constructionist philosophy and an interpretist epistemology. The nested research methodology continues with the development of an appropriate approach.

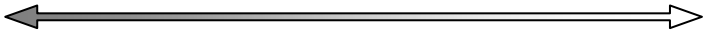
3.6 Research methodology - approach

The nature of construction, as a complex product with an enduring legacy, has generated its own academic research agenda, debates and theories (in comparison to, for example, textile industry management manufacturing for which there is no similar dedicated research tradition (Edwards, 1997, noted by Chau et al., 1998).

Research into construction management is 'at the intersection of natural science and social science' (Love et al., 2002: 294) so the research approaches that characterise the paradigms of these research disciplines are more usefully viewed as points on a continuum (Sexton, 2004). A range of research methods are identified that are appropriate to construction research, and these can be aligned along the broader philosophical continua which forms the basis of methodologies for the more established disciplines of natural and social sciences.

There are a range of potential research approaches that are available to the researcher and Table 3.1 (adapted from Sexton, 2004 and Pathirage et al., 2008) notes five key alternatives along the continuum, showing the extent to which the researcher is immersed in the process. Nomothetic[8] and ideographic[9] approaches are defined to differentiate between the use of quantitative, systematic data analysis techniques and the analysis of subjective accounts of the realities of everyday life (Pathirage et al., 2008).

Table 3.1 Range and characteristics of five research approaches

Experiment	Survey	Case study	Action research	Ethnography
Research into natural phenomena		Research into construction		Research into social phenomena
Nomothetic research approaches			Ideographic research approaches	
Deduction from theory			Induction from data	
Explanation via analysis of causal relationship			Explanation of subjective meaning systems	
Generation and use of quantitative data			Generation and use of qualitative data	
Testing of hypothesis			Commitment to research in everyday settings	
Highly structured			Minimum structure	
Experimental	Evaluative	Engaged	Embedded	
Researcher involvement				
				

[8] Concerned with establishing consistency and regularity (Crotty, 2003: 67)
[9] Concerned with individuals' perspectives (Crotty, 2003: 67)

The alternative research approaches are assessed in relation to the research questions, and the selection of a case study, as an evaluative approach, is justified.

3.6.1 Experiment

Within the positivist tradition of natural science, an experiment takes place in an isolated, controlled laboratory condition, where the effects of changing variables are controlled and measured to verify or refute hypotheses on research subjects (Grix, 2004; Kumar, 2005). Whilst an experiment may be appropriate for the testing of building components either in a laboratory or 'in situ' it is not a practical approach for construction management research or, specifically, as an approach for addressing the questions raised by this research which are anchored in the regulatory requirements for organisations in project-based business contexts.

3.6.2 Survey

A survey is designed to generate information from a sample, usually by questionnaire or interview, that can be generalised to a population with the objective of statistical validity (Fellows & Liu 2008: 23 & 151). The conduct of a survey via a questionnaire raises issues of non-response rates and potential respondent bias, and lacks the potential for explanation presented by an interview situation. A survey is an impersonal research approach with a non-involved researcher and lacks the opportunity for interaction and observation of the research subject in a natural context, thus placing it towards the positivist end of the epistemological continuum.

3.6.3 Case study

Case study takes an example of a situation or 'contemporary phenomenon' (Grix, 2004) in its natural setting, over which the researcher has little or no control (Yin, 2003), and uses and triangulates multiple sources of evidence to carry out a detailed investigation. As Table 3.1

shows, case study falls between a deductive, theory testing approach and an inductive, theory building research approach (Pathirage et al., 2008).

3.6.4 Action research

This approach addresses 'real world' issues, usually in a business environment, as an approach where the researcher participates and intervenes in a process of active and intentional change to improve the practice and understanding of processes by practitioners (Denscombe, 2003; Robson, 2002). Although it is 'project-reliant and context dependent' (Fellows & Liu, 2008: 21), action research is not an appropriate approach for this research because of the non-intervention of the researcher implicit in the observation of construction project participants working to meet the Code.

3.6.5 Ethnography

Ethnography requires the researcher to become involved and immersed in a group of people over a lengthy time period to describe and interpret the interdependencies of culture and social structure at a holistic level (Denscombe, 2003; Grix, 2004; Robson, 2002). The research, in focussing on the specific issue of regulation-driven innovation, is not concerned with the day-to-day interactions associated with the management of parallel projects and the minutiae of business life.

3.7 Justification of case study approach for this research

Having assessed these five key approaches, case study is the appropriate option for the nature of the phenomena being researched. There are two key justifications for this; first, the characteristics of the research problem, and secondly the expression of the research questions and these are expanded below.

3.7.1 Characteristics of the research problem

Proverbs and Gameson (2008) note Remenyi et al.'s (2002) account of a case study as a story drawing on multiple sources of triangulated evidence to understand and illuminate the central issue in its broader context. There is a specific focus on an organisation or situation (for the research, this focus is the commission, planning and design of homes to meet Code requirements), and this should be reasonably bounded in both time and space (where the situation is limited by its physical site and by the start, progression and conclusion of the pre-construction phase up to the granting of planning permission). Fellows and Liu (2008) note the problem-solving nature of construction research, where 'the situation is likely to be dynamic and so the variables are difficult to isolate...It may not be evident when a solution has been reached, and many alternative solutions are likely to be possible (Fellows & Liu, 2008: 8).

Although the use of a case study for research in the area of construction appears to be relevant as a preferred research approach for the complex, project-based situations of the construction sector, its use is assessed as relatively low (Proverbs & Gameson, 2008). However, by selecting a case study approach, this research facilitates a more 'fine-grained analysis of innovation processes' (Winch, 1998, as noted by Manley, 2008: 232) in an 'everyday' small-scale construction project where the focus of the research, the innovative capacity of project organisations, co-exists with other regional, local and site-specific circumstances and regulations.

3.7.2 Expression of research questions

The research questions are expressed as 'what' and 'how' and these are used as a clue to indicate that a case study is appropriate (Yin, 2003). Blaikie (2007:5) notes a hierarchy of research questions, starting with *What* that implies a descriptive answer, discovering and describing characteristics and patterns in social phenomena for a subject where there is limited previous or relevant research. *How* questions consider change,

intervention and practical outcomes. Yin (2003: 5), dealing specifically with research questions for case study, notes that a *What* question is a generic exploratory technique for all research approaches and is therefore valid for this research, and *How* generates explanations from operational links. Table 3.2, in comparing case study with experiment and survey as research approaches, confirms that a case study is appropriate for the nature of the research problem.

Table 3.2 Comparison of case study with experimental and survey approaches (Gomm et al., 2002: 4)

	Experiment	Survey	Case study
Number of cases	Small number	Large number	Small number, sometimes just one
Information gathered & analysed	Low number of features of each case	Small number of features of each case	Large number of features of each case
Control of variables	Controlled as a primary concern	Naturally occurring, but selected to represent a larger population	Naturally occurring
Quantification of data	A priority	A priority	Not a priority
Research aim	To test / develop theory or evaluate intervention	An empirical generalisation from a sample	To understand the case itself. The wider relevance of findings is conceptualised as a basis for 'naturalistic generalisation'

Two additional defining characteristics of the case study approach for this research are that it considers a single case, and that it is exploratory. These are discussed, and include a consideration of the potential methodological difficulties presented by the use of Yin's definition of an exploratory case in conjunction with a single case.

3.8 Justification for a single case study

Case study literature notes concerns with single case studies (Yin, 2003) and defends the use of findings from single case studies as a basis for

generalisation (Flyvbjerg, 2006; Kennedy, 1979; Evers & Wu, 2006). It is reasonable to ask how results from a single case study can be generalised (Yin, 2003), and the role of the researcher is to provide the reader with the information needed to judge the validity of the generalisability of research findings from a single case (Denscombe, 2003). Although there is an alternative view that generalisation from data is the responsibility of the second researcher, (Marshall & Rossman, 1999; Stake, 1995) this is assessed as inappropriate in the context of PhD research.

Yin (2003) notes the difference between statistical and analytic generalisation, where statistical generalisation treats the research subject as representative of a population in order to extend knowledge of a universe. This research provides analytic generalisation by using the results generated by the case study to expand and generalise from the purpose that supports the research questions (Yin, 2003: 10). The analytic framework is derived from the Complex Product System (CoPS) model, adapted by Winch (2005) to conceptualise innovation in the construction sector identified in the literature review. The research design for the case study, following Yin's blueprint for a single exploratory case study, is generated from this preliminary research purpose, thus justifying analytic generalisation.

Yin (2003:40-42) discusses five rationales which may be used to support a single case study. Table 3.3 lists these and notes their relevance to Project A, showing that, as a case study for research, it can be defended as typical, where a typical case will 'capture the circumstances and conditions of an everyday or commonplace situation' and the lessons learned will be revelatory for the sector and 'informative about the experiences of the average...institution' (Yin, 2003: 41).

Table 3.3 Project A and five potential rationales for a single case study (Yin, 2003: 45)

Rationale	Summary	Relevance for Project A
Critical case	Testing a well-formulated theory to confirm, challenge or extend it.	Not relevant as no specific theory exists for responding to Code 4.
Extreme / unique case	Unique or unusual, so worth documenting and analysing.	Not relevant as Code 4 will apply to all new housing.
Longitudinal case	Studying the same case at multiple points in time.	May be relevant as a follow-up study to investigate how innovation has embedded in processes.
Revelatory / exploratory case	Opportunity to observe a previously unavailable phenomenon.	Relevant, as Code 4 is new, and the study explores its impact.
Typical case	Capturing circumstances and conditions of a commonplace phenomenon.	Relevant, as Code 4 and innovation required to meet it will be applicable to all new housing.

Having used Yin's assessment of single case rationales, Denscombe (2003) further supports the justification for a single case by demonstrating that results arising from a typical case can be extended to other instances by summarising elements of comparison. These elements and examples are noted in Table 3.4 which summarises the features of Project A and shows how these compare with other housebuilding projects, justifying it as a typical single case.

Table 3.4 Single case study justification - Project A as a typical case (Denscombe, 2003: 33)

Element of comparison	Example	Project A case study	Housebuilding projects
Historical	Development, change	Design of homes to meet Code 4	Code 4 is required from 2013
Institutional	Type and size of organisation, policies and procedures	1. RSL client with HCA funding, national housebuilder. 2. Homes to meet range of regulatory and design requirements.	1. 58% of annual 240,000 new housebuilding target a year to be social / affordable / shared ownership from 2010 (DCLG, 2007a: 9-10) 2. Regulatory requirements apply to all housebuilding.
Physical	Geographical area, town, building	52 homes on a brownfield site	Small scale major developments have 10 - 199 units[10]
Social	Participants	Project partners include architect, civil engineer, local authority housing and planning, Highway Dept, HCA, construction and client staff.	Standard team for housing development projects.

3.9 Justification for an exploratory case study

The case study is exploratory (Yin, 2003) in that it investigates a new situation generated by the introduction of the Code and the urgent policy timescales in place for achieving higher Code levels. It accommodates Fellows and Liu's (2008) definition of an exploratory study as testing, or exploring, aspects of theory, where the theory is the framework for the organisational factors of innovation identified by Sexton and Barrett (2003) in conjunction with construction innovation within Complex Product Systems model (Winch, 1998) and the research considers the generation of appropriate innovation to meet the requirements of the Code for Sustainable Homes level 4 within this model. A descriptive case study would merely have identified and recorded the process of design and development.

[10] DCLG G. Kelly, personal communication, December 2010

3.10 Selection of case for study

The research methodology, designed to address the research questions generated by the literature review, requires a 'typical' case for study (Yin, 1994: 38). The criteria for such a case are summarised in Table 3.4 and crucially, these include a social housing project in the early design stage, meeting Code level 4, with a range of project partners that are typical at this project stage and all 'hospitable to our enquiry' (Stake, 1995:4), willing to take part in academic research, and coinciding with the second year of the three year PhD research timetable. Table 3.5 extracts evidence from statistical data on Code housing (DCLG, 2011) where design-stage Code certification is assessed following planning approval. If Project A, as a typical case study within the criteria noted above, had achieved planning permission and a start-on-site during 2008 - 09 as originally intended, its 51 homes would have been added to the 21 actually certified (giving a total of 72) and represented 71% of Code 4 homes potentially given design stage certificates during the year. An actual February 2011 completion for Project A represents 53% of post-construction certificates for this month. Appendix 3.1 provides the data to support the selection of Project A as a case study on this basis. Additionally, to September 2011, the local authority has 167 Code design-stage new homes and 109 completions, of which Project A's Code 4 homes represent 31% and 47% respectively (DCLG, 2011).

Table 3.5 Justification of Project A as a research case study – supporting data (DCLG, 2011a)

Time frame	Code 4 certificates recorded	Total certificates	Project A – 51 homes as % of total
Apr 08 – Mar 09	Design stage	21	71%
Feb 11	Completion	97	53%

Project A is suitable as a case study for the purposes of the research as a typical social housing development project delivering innovative housing to meet the requirements of the newly-introduced Code within the timeframe

specified and in the context of a competitive market environment. The design stage of Project A is relevant for case study because it involves eight organisations actively involved in the early stages of housing construction that can be identified across the CoPS model of innovation, as expressed in Figure 3.3 and used as an analytic motif for the research questions. Each organisation works to their own 'given environment' regulations and standards and brings these to the project in a complex mix of innovation, negotiation and compromise. Figure 3.3 forms a framework for the research analysis and is used as a consistent basis for visual capture of research themes and conclusions, referencing the innovation structure of complex product systems as a background for analysis of Project A's data.

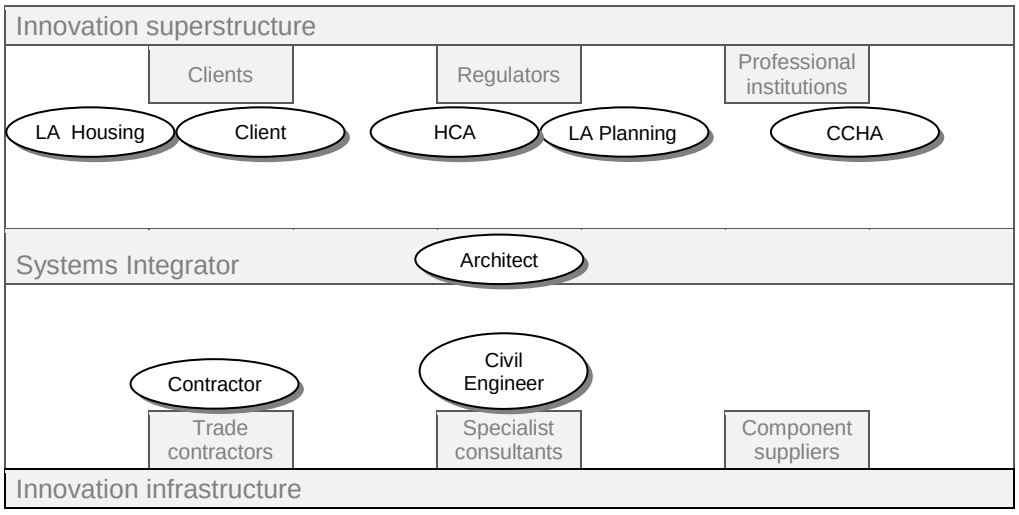


Figure 3.3 Project A participants and CoPS model of construction innovation (Winch, 1998)

The architect is justified as a Systems Integrator (SI) for the case study within the CoPS model. Rutten et al. (2008) identify the role and characteristics of a CoPS Systems Integrator from their comprehensive review and synthesis of literature on innovation and inter-organisational co-operation. A CoPS SI is defined as a firm that designs a complex product at the interface of the innovation superstructure and innovation infrastructure adding value by 'integrating components, technologies, skills and knowledge' from organisations across the sector, with a contractual

responsibility to an individual client (Rutten et al., 2008:286). Winch (1998) explicitly extends this to a construction context and identifies the SI role as shared between the architect and the contractor at the design and construction stages of a construction project. This supports the concept of the research project as a dynamic process and justifies the identification of the architect as the SI in the design stage of Project A, and this decision is supported by the subsequent case study data analysis.

A secondary basis for the selection of Project A is that the case is, in itself, intrinsically interesting and justifies investigation on behalf of the project participants because of the physical challenges presented by the site itself (Stake, 1995) which enable the researcher to 'investigate phenomena in depth to provide rich description and understanding' (Darke et al., 1998: 227).

3.11 Case study description

The case study is described in detail here to reflect its richness and complexity both as an exploratory, revelatory case of housing development built to Code level 4 which will become mandatory for all new housing from 2013, and as an inherently interesting early-stage project. The project is referred to as Project A, and the site itself as Smith Lane.

Smith Lane is a two acre site, owned by the local authority, to the north of an East Midlands town. The terrain is rough scrubland with a significant 6 metre slope from the north west to the south corners. There are a range of physical challenges on the site, including boundaries of a railway to the west, a dual carriageway to the north, a brook to the east and an unadopted lane to the south which gives its name to the site. Figure 3.4 provides an aerial image of the site (Microsoft Virtual Earth, accessed May 2011) and additional photographs are included at Appendix 3.2.

Figure 3.4 Smith Lane site (outlined in red)

The local authority's 1996 Borough Plan identified the site for social housing as part of a larger three-part allocation including the case study site and two neighbouring fields. The first site was completed by a national housing contractor in 2001, and the project contractor completed the adjoining site in 2004. Following the housing association's development of a nearby EcoHomes scheme, the local authority were prepared to give the Smith Lane site for free in return for the development of 52 homes built to Code for Sustainable Homes level 4. The council's Strategic Management Team approved the donation of the land and the HCA agreed a grant.

The site entrance design was influenced by the ownership of an adjacent corner plot of land and the road layout reflects the need for a loop rather than a cul-de-sac. The homes were designed to mitigate noise from the A43 across the site.

Changes to the original concept were amended during the design phase. The number and layout of homes was altered following a re-assessment by the council of their requirements, reducing the number of flats and increasing the bungalows, with a revised total of 51 homes. The financial

plan, based on the outright sale of a number of homes to part-fund the development, was amended by the housing association client to reduce the homes for sale in the context of the collapse of the housing market in late 2008. As a result of these adjustments the client returned the grant to the HCA pending further analysis of the changed circumstances.

After the council Executive Committee's eventual approval to give the land away, a planning application was made in March 2008 and turned down in October 2008 because of local concerns about noise and flooding. The planning permission process for Smith Lane, from the perspective of the local authority planning team, was normal, making steady progress through the standard process. However, staffing issues within the department contributed to delays within the process, exceeding the specified timescales. The project team re-submitted the planning application on November 2008 and permission was given in January 2009.

Following planning permission, two key issues delayed construction. First, the ownership of the section of Smith Lane itself that gives access to the site continued to present a legal complication which may compromise the adoption of the access road and ultimately the roads around the site. The neighbouring development, also constructed by the contractor, does not yet have adopted roads because their access also crosses Smith Lane. This road includes the ransom strip owned by the contractor leading across Smith Lane to the site. A claim was made for Smith Lane to be designated as a restricted byway, giving it public status and enabling it to be adopted. The claim precedes the construction of the road into the site. The client took an insurance policy to manage and control the risk of any work carried out across the unadopted Smith Lane.

Secondly, the client re-negotiated a grant with the HCA to bridge the financial shortfall generated by the alteration in the mix of volume and tenure and to reflect the build cost agreed between the client and the

contractor. This was subject to the HCA's usual grant conditions, including an agreed date for completion. The HCA's requirements generated a cost constraint on finalising the contract between the client and the contractor and a time constraint on construction. The contractor's technical specifications required to meet Code 4 within the constraints of the budget were finalised and the legal teams began completing the contract details. At this stage the agreed case study research was completed with a second workshop, however continuing progress is briefly noted here to complete the story of Smith Lane.

A start-on-site date during November 2009 was critical in order to achieve completion by February 2011 to meet the HCA's timescale. The start date depended on offsite work to satisfy Highway Authority and planning approval conditions, including 'small works' on approach roads to support access to the site and in line with the Section 278 agreement (which enables developers to alter roads defined as public highways).

In late November 2009 (after the case study data collection was completed) the contractor's Board decided to pull out of the project. The client purchased the contractor's ransom strip and invited tenders for the construction with a start date of early 2010, with completion planned for early 2011. An alternative contractor was engaged, building started during March 2010 and was successfully completed within the HCA's timescale. Figure 3.5 shows the client's site plan for shared ownership homes (accessed May 2011) which uses a similar layout to the one originally designed by the case study project team.

Figure 3.5 Smith Lane site plan

3.12 Research approach - summary

Table 3.6 references the nested methodology at Figure 3.1, linking the research problem of the study of the Code in housing design projects to a philosophy with which it shares an 'elective affinity' (Knox, 2003: 124) and to the characteristics of a single exploratory case study as a research approach that is appropriate for the problem.

Table 3.6 Defining the research problem and case study approach in the context of an contructionist philosophy

Research philosophy (Sexton, 2004)	
Positivist	**Interpretist**
Realist	**Idealist**
Value-free	**Value-laden**
Research problem	
Abstract	**Complex**
Discrete	**Messy**
In isolation	**In context**
Natural	**Social**
Objective	**Subjective**
Testable	**Observable**
Research approach (Pathirage et al., 2008)	
Deductive	**Inductive**
Theory to data	**Data to theory**
Theory-testing	**Theory-building**
	

Following the nested approach, the philosophy that informs the approach to the research takes a perspective that tends towards contructionist whilst recognising the benefits of a structured and rigourous approach as recommended by Yin (2002). The case study approach has been considered in detail and justified as relevant for addressing the research questions. A single exploratory case study has been defined as an appropriate research approach, and the case for study has been identified and described as a starting point for the development of the case study design as the third element of the nested research technique.

3.13 Research methodology - technique

Having defined and justified a case study as an appropriate research approach, this section discusses decisions on specific aspects of case study design method which inform the design of a piece of research that satisfies the academic criteria for social research methodology that is valid and reliable, regardless of the research's (and the researcher's) epistemological stance of positivism or interpretism.

This section relies heavily on Yin's work as he 'has done much to resuscitate case study as a serious option when doing social research (Robson, 2002: 178). In addition, Yin's 'insistence that case study method be done in conformity with science's goals and methods' (Yin, 2003: x), 'bringing the concerns of validity and reliability in experimental research design to the design of case study research' (Eisenhardt, 1989: 534), fits the philosophical position of the research.

3.14 Four conditions of good empirical social research

Before discussing the design of the case study, the four commonly-used critical conditions for testing the quality of empirical social research, described as construct, internal and external validity, and reliability (variously referenced, e.g. Kidder & Judd 1986, noted by Yin, 2003; Flick, 2006, Chapter 28) are noted. Yin's development of advice on tactics (summarised in Table 3.7) for addressing these in the design of the case study is acknowledged and use of the tactics themselves is described.

Table 3.7 Case study design tactics for meeting four conditions of good empirical social research (Yin, 2009)

Tests	Case study tactics	Research phase for tactic
1 Construct validity	Use multiple sources of evidence	Data collection
	Establish chains of evidence	Data collection
	Have key informants review draft report	Composition
2 Internal validity	Do pattern matching	Data analysis
	Do explanation building	Data analysis
	Address rival explanations	Data analysis
	Use logic models	Data analysis
3 External validity	Use theory in single-case studies	Research design
4 Reliability	Use case study protocol	Data collection
	Develop case study database	Data collection

3.14.1 Construct validity

Yin (2009) notes that a criticism of case study research is the potential subjectivity of data collection due to a lack of operational measures. Yin's

example (2009: 42) of neighbourhood change is amended here to reflect innovation in the two case study design tactics recommended to ensure construct validity;

- Define innovation, regulation and project in terms of specific concepts, and relate them to the original objectives of the study;

The research on the nature of regulation-driven innovation focuses on the specific concept of the capacity of housing project teams at the development and design stages to innovate to meet sustainability regulations, as articulated within the given and interaction environments of Sexton & Barrett's (2003) model. This relates directly back to the research objectives, discussed in Chapter One, Section 1.4.

- Identify operational measures that match the concepts, preferably citing published studies that make the same matches;

The operational measures used to define the development of innovation are expressed by the tiers of innovation superstructure, infrastructure and Systems Integrator of the CoPS model applied to construction (Winch, 1998) identified in relevant literature (reviewed in Chapter Two, Section 2.8.3) as appropriate for understanding innovation in the sector, which informs analysis of research data.

Having established construct validity, this can be further supported by three devices listed in Table 3.7. First; multiple sources of evidence encourage convergence; secondly, a chain of evidence develops a logical progression towards this convergence; and thirdly, project participants are asked to review a draft case study report. These devices are reflected in the case study design.

3.14.2 Internal validity

Yin (2003) notes that the role of internal validity in social science research is well-referenced in textbooks and journals, and extracts two points that are directly relevant to the design of good case studies.

Although the causal logic of the first point is not relevant for exploratory case study, where a potential causal relationship between events is not under consideration, a familiarity with the concept is usefully reflected here. A relationship may be incorrectly identified between event *x* and event *y* when *z*, as a third unknown factor, may have caused event *y,* thus the potential existence of *z* threatens the internal validity of the research and should be tackled.

Secondly (and of relevance to all case studies) the issue of inference is involved whenever an event cannot be directly observed by the researcher (for example reported in meeting notes or described during interview). How can the inference be verified? Have alternative explanations been considered? Is the evidence convergent? A good research design will address problems associated with inference, however Yin notes that specific tactics are difficult to identify. Table 3.7 suggests pattern matching, explanation building, addressing rival explanations and using logic models as tactics to be used during data analysis, and these are reflected in Section 3.19 on data analysis.

3.14.3 External validity

The external validity of social science research relates to the generalisability of the findings, noting the criticism for this research that the use of a single case study is generally considered to be a weak basis for generalisation. This criticism is addressed and refuted in detail in Section 3.8. However with specific reference to external validity, the design of a good case study should incorporate the issue of generalisability by addressing the logic of replication (as a tactic noted in Table 3.7) that

applies to experimental research and enables scientists to cumulate knowledge across experiments. The logic of replication, though, is not necessarily relevant for single case studies, so external validity is ensured by use of the same principles of analytic generalising to theory, noted in Section 3.8.

3.14.4 Reliability

The fourth criterion of good social science research relates to reliability where the goal is to minimise error and bias, such that the same results, findings and conclusions would be reached by a different researcher or at a different time. Yin (2009) recommends the development of a case study protocol to ensure that the research is replicable and achieves the auditability and transparency normally associated with accountancy or bookkeeping. The protocol is a practical summary of the case study design decisions and defines how the case study should proceed. It should specify how the researcher intends to answer the research questions and provide a link back from the data to the questions. This level of detail enables a flexible approach if circumstances change. The case study protocol for this research, based on Brereton et al., (2008) who adapted their template on research into the investigation of systematic literature reviews in software engineering to provide a generalised model for common use, is included at Appendix 3.1 and the use of a research database is noted in Section 3.15.5.

3.15 Case study design

Having considered the four criteria for the design of good empirical social research, these are applied within the case study design. Yin (2003) points out that good case studies are hard to do for four main reasons. These are a perceived lack of rigour, little basis for scientific generalisation, length of time and volume of data resulting in long, dense reports, and the absence of a defined skill-set for researchers. The challenge is to design a good case study that addresses ‘the traditional criticisms of the method’ (Yin,

2003:1) by being rigorously designed; with a sound basis for generalisation; relevant and timely reporting back to industry; and carried out by a self-aware researcher, resulting in research that is a credit to the discipline.

Yin (2003) provides seminal guidance on case study design that addresses the methodological requirements for research to be objective, valid and reliable. A good research design should incorporate five key components; research questions; propositions or purpose; unit of analysis; logic linking data to propositions; and criteria for interpretation of findings (Yin 2003: 21). These are discussed below and are represented in the case study design at Appendix 3.4.

3.15.1 Research questions

The research questions emerged from the literature review and are expressed as 'what' and 'how' queries, as discussed in Section 3.7.2. and reprised here as:

1 What is the impact of the Code for Sustainable Homes on the early stages of social housing development projects[11]?
2 How do social housing development projects innovate[12] to meet the Code for Sustainable Homes?

3.15.2 Research propositions

Research propositions are essential for directing the detail of the research for explanatory case studies. However, research propositions are not appropriate for an exploratory case study, which instead benefits from a clearly stated purpose about what is to be explored, the aim of the exploration and the criteria for judging the success of the exploration (Yin,

[11] Where project is defined as 'a temporary, formal group of organisations with a specific objective'.
[12] Where innovation is defined as 'the process of a successful application of a new idea that adds value'.

2003: 30). For this research, the purpose is to generalise the findings to the theories of innovation generated by the literature review, using a combined model of the innovation structure for Complex Product Systems (Winch, 1998) within the given and interaction environment of Sexton and Barrett's model of the organisational factors of innovation (2003) as a starting point.

3.15.3 Unit of analysis

The unit of analysis defines the subject of the case study and is a fundamental element of thorough research design. A carefully considered unit of analysis implies a 'system of action' (Tellis, 1997: introduction) linking well-defined research questions to the collection of data by identifying information which is relevant to the case, including clear boundaries of both time and people, to define the limits for data collection and analysis. A sound unit of analysis will guard against any confusion between data collection sources (e.g. people, documents) and the subject of the research. Conversely, a weak or irrelevant unit of analysis implies that 'everything' may be studied, which is not possible (Yin, 2003: 23), nor is it good research. The unit of analysis is thus expressed as the innovation needed to achieve Code 4. This clarity links the research questions and hypothesis through to the sources of data, and enables the specific issues of the unique site location and its physical challenges, which are important to participants but not of primary relevance to the research questions, to be separated during data analysis.

3.15.4 Logic linking data to purpose

This logic is shown in the case study design at Appendix 3.4. Although this research, being exploratory, does not make use of a theory-testing proposition (as noted in Section 3.15.2) the purpose (as an alternative) and data are logically linked by the semi-structured interview questions which explicitly capture evidence of capacity for innovation from

organisations within the Complex Product Systems (CoPS) model, and the additional data which contextualises this capacity.

3.15.5 Criteria for interpretation of findings

The research design reflects three key principles noted by Yin. First, the design includes multiple sources of evidence. These are noted in Section 3.17 and the extent of these supports the generation of robust research conclusions. Secondly, the design makes use of a case study database. This research, including the case study, has made extensive use of NVivo both as content analysis software and for its capacity to capture and organise many sources of data, ideas, thought processes and links between these. At the same time, the researcher is aware that 'software cannot...compensate for limited interpretive capacity' (Bazeley, 2007; 3). The use of software, and specifically NVivo, both as a project database and to support content analysis, is discussed and justified in Section 3.19. Thirdly, the design should demonstrate a chain of evidence, to establish a clear link from the final case study report back to the research questions via the database of multiple sources of evidence, supporting the research as a coherent whole. The research design at Appendix 3.5 reflects this coherence.

3.16 Selection of case study participants

The case study participants were the members of the project development team for the early stages of the project. Participants were key decision makers for their organisations, contributing different perspectives on the processes and decisions. The selection of a number of knowledgeable interviewees generates a range of different perspectives on the research case study (Eisenhardt & Graebner, 2007: 28) and enables data analysis across the Complex Product Systems (CoPS) model of construction innovation as noted in Table 3.7.

The housing association's Director of Development was the initial key contact for the research. Names and contact e-mail addresses were provided for members of staff at the seven other organisations (contractor, architect, engineer, county council highways team, local authority planning and housing teams and the regional Homes and Communities Agency) who were directly involved in the early concept, design and planning stage. Introductory e-mails were sent by the researcher and all seven contacted individuals agreed to take part in the case study, committing to interviews and participation in the subsequent workshop.

3.17 Data collection

Data collection took place over a critical four month period for the project, in which the design of sustainable housing to meet regulatory requirements was played out against a general background of housing market crisis and, more specifically, the unique design demands of a challenging site. The interview data was thus fresh and immediate, collected in a 'real time' context from participants engaged in a current situation rather than reflecting on past events.

Data was generated by interviews and their transcripts, general organisational and project-specific documentation from participants and available on the internet, workshops and site visits. Each source presents a potential compromise to the overall quality of data generated and, therefore, on the ultimate validity of the research (Love et al., 2002). A critical awareness by the researcher of these issues can reduce or mitigate these effects and this is reflected in the case study design.

3.17.1 Semi-structured interviews

'The personal contact and the continually new insights into the subjects' lived world make interviewing an exciting and enriching experience' (Kvale, 1996: 124) and this is emphasised in the collection of data from the semi-structured interviews within the case study design. Interviews are

a primary source of data for case study technique, and these take a structured, semi-structured or unstructured format (Yin, 2003). The styles describe the degree of constraint placed on both the researcher and participant by the form of the questions, where a semi-structured interview is a focused or guided conversation following a series of open questions defined to meet the purposes of the research. (Fellows & Liu, 2008; Yin, 2003).

An interview situation raises two specific issues for the researcher. First, an interview question is not just a 'neutral invitation to speak', and responses to questions become 'accounts' rather than 'reports' of events (Fellows & Liu, 2008: 156). Garfinkel, (1967, noted in Blaikie, 2007: 142) argues that an account is a socially mediated narrative within a specific context (in this case an interview situation) where participants reinforce the type of transaction they are involved in (in this case, an interviewer and interviewee). The second issue is one of reflexivity (noted by Yin as a weakness of interview as a source of data) where an account is only relevant in the social context of the interview (Garfinkel 1967, noted in Blaikie 2007: 142). Thus the value to the research of the narrative generated by an interview needs to be recognised by the researcher as a perspective that accurately reflects, for the participant, the case being studied, rather than a report of the case itself. Multiple perspectives thus serve to balance and neutralise the shared account of the case study (Eisenhardt & Graebner, 2007).

The semi-structured questions (summarised at Appendix 3.6), distributed to participants by e-mail in advance of the interviews, were designed to be open-ended and neutral, focussing on the process and 'story' of the case study to facilitate an exploration of participants' perceptions and perspectives on achieving Code 4 homes in the context of a project design and planning phase. The interview format enabled participants to offer additional information, comments and views, and provided opportunities

for the researcher to invite and probe for clarification and extension of these. Table 3.8 summarises the interviews, using the organisations' CoPS roles.

Table 3.8 Semi-structured interview summary

CoPS role	Organisation	Job function	Time
IS	Local Authority Housing Team	Housing Strategy Officer	1h 0m
IS	Client	Head of Construction	1h 15m
IS	Homes and Communities Agency	Investment Manager and Design & Standards Adviser (together)	1h 17m
IS	Local Authority Planning Team	Development Officer	49m
IS	County Council Highway Authority	Development Liaison Team Leader	1h 6m
SI	Architect	Architect	1h 15m
II	Contractor	Senior Land Manager	1h 26m
II	Civil Engineer	Associate Director	1h 4m
IS – Innovation superstructure SI – Systems Integrator II – Innovation infrastructure			

Recording and transcribing provides a full and accurate record of the interview and reduces potential researcher bias or selectivity in note-taking and recall. It is also noted that recording is no substitute for listening (Yin, 2003). Interviews were recorded with the consent of the participants and transcripts were prepared by the researcher. This exercise provided a valuable overview of the data as a starting point for analysis. Transcripts were checked by participants for accuracy and to answer specific queries and clarify points. In addition, this exercise provided a source of triangulation (Stake, 1995). A representative verbatim interview transcript is included at Appendix 3.7. The interviews provided over 9 hours of recorded material and the transcripts yielded over 55,000 words of text as a basis for analysis.

3.17.2 Documentary evidence

The transcripts were supplemented with general and project-specific documents both provided by participants and available on the internet. These included architects' and engineers' plans, schedules of data for calculating CO_2 emission reductions, documents associated with applying for planning permission and copies of letters between participants, listed at Appendix 3.9. These are used as part of the case study evidence with the awareness that documents are generated within specific business contexts and should not be viewed as objective and independent (Yin, 2003; Fellows & Liu, 2008).

3.17.3 Workshops

Two workshops were held during the course of the case study. These provided a contrast to the interview situations, enabling participants to work together to generate a shared agreement or 'cohesive consensus view' (Fellows & Liu, 2008). The purpose within the research design for the workshops was to encourage, observe and record interaction between participants in group situations. Additionally, the use of workshops mitigates any effects of bias from research and from project participants (Darke et al., 1998:285) and generated independent observer triangulation by including members of the academic research team.

3.17.3.1 First workshop (W1)

The first five hour workshop was held before the series of interviews, with the intended outcome of agreeing the purpose, format and content of the case study for the participants. This was achieved via presentations and discussions, resulting in a draft summary which was discussed, amended and agreed as a reflection of participants' expectations and the requirements of the project to form a case study for research. The summary is attached at Appendix 3.8**,** showing the processes and decisions around the key issues of the development, and the research methodology of interviews, project documentation, cross-case analysis

and workshop, and for investigating and reporting on these for the participants.

3.17.3.2 Second workshop (W2)

The purpose of the second five-hour workshop was threefold. First, it provided a source of significant triangulation of interview evidence through a purposeful and structured opportunity for individual participants to review their own and each-others' accounts of the events and processes of the early stages of Project A. Secondly, it generated additional documentary evidence in the form of participants' notes and comments on the interim report, and a written record of discussions in response to emerging semi-structured questions. Thirdly, it enabled the research project participants to review the interim report prepared from evidence generated by transcripts and documentation on the timeline, risks and decisions of the development.

The five workshop participants were the same key decision makers who had been interviewed by the researcher, representing the organisations who were directly involved in the design, and the design process, for Smith Lane. The workshop participants' organisations were spread across Winch's CoPS model of innovation, reflected in Figure 3.3 for the case study, further supporting justification of the use of this to inform data analysis. Figure 3.6 shows workshop participants within this model.

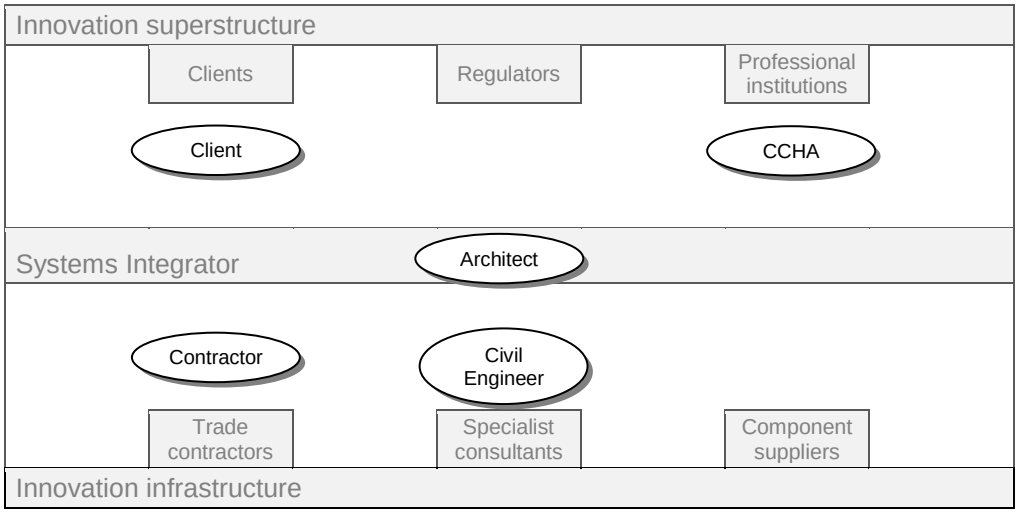


Figure 3.6 Second workshop participants and CoPS model of construction innovation

3.17.3 'Direct observation' - site visits

Two independent visits were made by the researcher to the site for 'direct observation' (Yin, 2003: 92). It was not possible to access the site itself due to the boundaries of a dual carriageway, railway, fence and brook. The visits provided a strong visual context for the case study recorded in a series of photographs (at Appendix 3.2), supported by evidence from Ordnance Survey (OS Landranger map 141) and Google Earth maps and the architect's and engineer's plans, and confirmed descriptions of the site by project participants. Data collected during the visits were used to add value to the researcher's understanding of the design of homes to optimise solar gain, and of the detailed design of access to the site.

3.18 Triangulation of data

Case study data triangulation relies on multiple sources of evidence collected from different sources and at different times, as noted above, to strengthen research conclusions (Yin, 2003) and to overcome problems of bias (Love et al., 2002). Triangulation compensates for any potential weakness in one data source with strength in another, to 'exploit the assets and neutralise...the liabilities' (Jick, 1979, noted in Fellows & Liu, 2008). Interview transcripts were treated as the primary data source and

triangulated against the additional documentary data provided by case study participants and the researcher's direct observations. Appendix 3.9 details the data used for triangulation, and this is summarised in Figure 3.7.

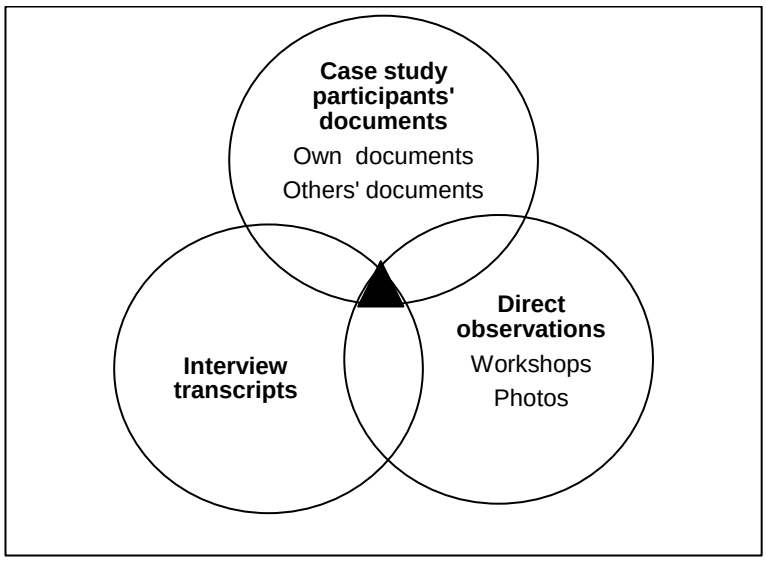


Figure 3.7 Summary of data sources for triangulation

3.19 Data analysis

Given that the data collected on the case study is text-based (as original written documents, transcribed interviews and researcher notes), text analysis is appropriate as a tool for the 'interpretation of the content of text data through the systematic classification process of coding and identifying themes and patterns' (Hsieh & Shannon, 2005). The aim is to classify large amounts of text into categories that represent similar meanings, to provide an understanding of the research subject. The flexibility of content analysis is regarded as a strength by researchers who also need to mitigate against any lack of clarity and definition that may limit its application (Hsieh & Shannon, 2005), thus it should be noted that the skills and reflective self-awareness of the researcher are of importance in the content analysis process, which should be planned so that a subsequent analysis of the same data by another researcher generates

the same analysis; that the process is verifiable and repeatable (Yin, 2003; Denscombe, 2003).

Data analysis for the research takes a conventional approach as identified by Hsieh and Shannon (2005), which is appropriate when 'existing theory or research literature on a phenomenon is limited' (Hsieh & Shannon, 2005: 1279), for example around the Code as a new regulation. The advantage of the conventional approach is that information can be gathered before codes and categories are identified and the framework for the analytic strategy was drafted within this approach.

3.19.1 Analytic strategy

Yin's view is that a high quality analysis is a 'persistent challenge' and 'one of the least developed and most difficult aspects' of a case study (Yin, 2003: 109) and recommends an analytic strategy as a framework for data analysis. Three alternative strategies are noted. First, the use of the theoretical proposition is not selected because this research is theory building rather than theory testing and thus there is no theoretical proposition or hypothesis to be tested. Secondly, testing for rival explanations is not relevant for this research because the research questions and unit of analysis focus specifically on innovation in response to the Code for Sustainable Homes as a new regulation, thus a test for rival explanations for its impact and resultant innovative responses are not appropriate. Thirdly, although Yin asserts that a case description is a 'less preferable' analytic option, it is appropriate for descriptive case studies. This research is exploratory in that the Code for Sustainable Homes is a newly introduced regulation, however it is based on a description of its impact and innovative responses and so an analytic strategy based on the construction of a case description is valid.

The outline of the case description analytic strategy is based on the three-tier structure of the Complex Product Systems model (innovation

superstructure; Systems Integrator and innovation infrastructure; Winch, 1998) and analysis is guided by the given and interaction environments defined by Sexton and Barrett's (2003) model of the factors of innovation.

3.19.2 Data analysis techniques

Four techniques for data analysis are applicable for a case description analytic strategy, as follows. First, pattern matching compares an empirical pattern observed in the data to one that has been predicted. Secondly, explanation building aims to use case study data to generate an explanation; a technique 'fraught with danger' (Yin, 2003: 122). This is of particular relevance for explanatory case studies, or where cases are the basis for grounded theory as a way of developing ideas for further research. Thirdly, a time series analysis generates a chronology to show how and why events occur over time, and finally analysis of logic models, comparable to pattern matching, compares empirical to predicted events using deductive cause and event patterns over time. For this research, the use of pattern matching and explanation building does not support the research questions, and logic modelling is not appropriate for a project-based situation because different organisations within the project have different cause and effect drivers.

However, the use of the data collected to generate a time series analysis is a useful and productive analytic technique, providing a robust foundation for case study findings (Yin, 2009). For this research, a time series analysis was developed to accommodate both a project situation and innovation in this context as a dynamic process. Miles & Huberman (1994) detail a range of analytic data manipulations for a 'timeline' narrative, used to inform the detailed case study description at Section 3.11 and as a conceptual framework for analysis of the innovation process in response to regulatory constraints. (Additionally, this was particularly useful as a preliminary 'handle your rat' (Bazeley, 2007: 44) exercise in

data immersion.) The use of a time series analysis contributes to the case study's internal validity, as noted in Section 3.14.2.

3.19.3 The use of software for text analysis

The value of the use of software as a coding and analysis tool continues to be debated, noting in particular that software is not an alternative to the researcher's capacity to analyse data (Easterby-Smith et al, 2002; Bazeley, 2007). It does, however, help the researcher to be more methodical, thorough and attentive by assisting in managing data and ideas, querying data, modelling and reporting (Bazeley, 2007: 3). This research made use of NVivo version 8.0.148.0, developed by QSR International[13], as a widely available package provided and supported by the university and extended with a range of academic literature on its uses and functions for qualitative research.

The primary data sources for the research were the eight interviews transcribed verbatim into Word documents and imported to NVivo as a starting point for the researcher to generate nodes and use these as a foundation for coding. A series of NVivo nodes provides a flexible framework for the researcher to identify, sort, link and synthesis themes and threads across data sources. Free nodes capture single ideas but have no structure, useful as a starting point or holding area, and tree nodes are hierarchical, with the capacity for sorting and dividing details as 'siblings', 'parents' or 'children'. Conceptually, a node is a single or multiple hook above the data on which the researcher can hang words and phrases. The development of nodes and associated coding of text data is noted as a fluid and iterative process in which some coding decays and some flourishes and informs the development of sub-codes. Coding and re-coding can be assessed as complete 'when the analysis appears to have run its course – when all of the incidents can be readily classified, categories are saturated and sufficient numbers of regularities emerge

[13] www.qsrinternational.com

(Miles & Huberman, 1994: 62) within a conceptual and coherent order that has meaning for the research.

For this research, the initial generation of the nodes was directed by the focus of the research questions; RQ1 on the Code as a regulation and RQ2 on innovation in response, and extended by the framework provided by the given and interaction environments of Sexton & Barrett's (2003) background for the organizational factors of innovation and Winch's (1998) hierarchy of innovation in Complex Product Systems. The final node list is included at Appendix 3.10. The CoPS hierarchies, as the framework for analysing data within the nodes and coding described, were simply accommodated with the use of attributes added to data sources.

Having established both an initial noding structure and attribute coding for CoPS roles, the data sources were read, re-read and reviewed, and words, phrases and sentences were coded at appropriate nodes in a sequence of iterations to refine and to extend the detail of both the nodes and their coding. These cycles continued until text was sufficiently coded at relevant nodes to support analysis of themes and ideas in order to address the research questions.

3.20 Case study design checklist

Having discussed the various elements of the case study, a final quality control for the case study design, which gives the research additional credibility, is considered. Brereton et al., (2008) recommend the use of Runeson and Höst's checklist (2008) summarised in Table 3.9.

Table 3.9 Case study design checklist (Runeson & Höst, 2008)

Item	Design checklist	Response
1	What is the case and its unit of analysis?	Noted in Sections 3.11 & 3.15.3
2	Are clear objectives and preliminary research questions defined in advance?	Yes
3	Is the theoretical basis defined?	Yes
4	Are the researcher's intentions made clear?	Yes
5	Is the case adequately defined?	Yes
6	Is a cause-effect relationship under study?	No - not relevant to research question
7	Does the design involve data and method triangulation?	Data - yes Method - no, because a single case study has been justified.
8	Is there a rationale behind the selection of subjects, roles, artefacts, viewpoints etc.?	Yes
9	Is the specified case relevant to validly address the research questions (construct validity?)	Yes
10	Is the integrity of individuals and organisations taken into account?	Yes - Ethical Approval

3.21 Accommodating additional ideas

Although the case study has been designed to support the research questions and generate knowledge that can be used to extend and refine theories of construction innovation and regulation, it is noted that semi-structured interviews, in addition to responses that have direct relevance to the research, are likely to prompt narratives, perspectives and thoughts about the Code that have not been anticipated within the research design. Additionally, the research problem exists in a messy, real-world context and a case study approach enables the researcher to locate the research subject in its context, as reflected by case study participants. As the Code is a major new regulation this research into its impact needs to recognise first; that the sector may have additional views on the Code and its context that are not accommodated within the research design and secondly; that it may be of value to the research synthesis and conclusions to recognise and consider these as part of the analysis in Chapter Four.

3.22 Methodology - summary

The philosophical position of the research has been justified as constructionist, and a single exploratory case study has been identified as an appropriate technique for addressing the two research questions. The case study has been developed with attention to the four conditions of empirical social research. The overall research design, the case study design and the research protocol have been presented, and data collection and triangulation methods have been outlined. A framework for data analysis that enables the researcher to address the research questions using content analysis supported by NVivo software has been proposed and justified. Analysis and results of case study data are considered next in Chapter Four.

**The Code for Sustainable Homes:
what are the innovation implications
for the social housing development sector?**

Chapter Four: Analysis and discussion

4.1 Introduction

This chapter records the outcome of data analysis and proposes answers to the two Research Questions within the analysis strategy considered in Chapter Three. Analysis for Research Question One addresses the Code for Sustainable Homes as a regulation within the project's given environment and its impact on the early stages of the design process. The cost of meeting the Code exerted considerable pressure on Project A and this is addressed as a separate section. Analysis for Research Question Two investigates how early-stage design projects innovate to meet the Code within an interaction environment. The two Research Questions are considered separately below, and findings are discussed and substantiated in the context of the innovation structure of Complex Product Systems proposed by Winch (1998) for construction projects.

4.2 Research Question One - what is the impact of the Code for Sustainable Homes on the early stages of social housing development projects?

4.2.1 Introduction

First, the terms 'impact' and 'early stages' used within the Research Question are defined to illuminate the subsequent analysis and conclusions.

'Impact' is defined as a strike or collision (Oxford English Dictionary Online) and as a 'measure of the effects or consequences of one thing's action or influence on another' (Business Dictionary Online). In the context of this case study, 'impact' is defined as the effect or influence of the Code, as a new standard, on a housing development project. This definition is extended with the use of the DBIS Impact Assessment Guidance (2011) which notes that an impact assessment explores 'proposals that best achieve the policy objectives while minimising the

costs and burdens imposed in achieving the objectives' (DBIS 2011:4). The document does not explicitly define impact.

Following case study design advice to clearly identify the time span of the case, for this research the 'early stages' of the inception and design of Smith Lane are formally defined as the start of the active involvement of the project partners in designing the layout of the plot and its homes in order to achieve planning permission, ending with the granting of planning permission by the local authority.

Case study data generated by semi-structured interviews, workshops and supporting documents relating to the Code is analysed using the analytic strategy as described in Chapter Three, Section 3.19 to illuminate the impact of the Code, as a factor within the project's given environment as defined by Sexton and Barrett (2003), on the design phase of Smith Lane as a typical Code 4 development.

4.2 Impact of Code criteria on the design of Smith Lane

Data analysis shows that the nine criteria of the Code, as tabled in Chapter Two, Table 2.7, have varying degrees of impact on the design of Smith Lane, summarised by participants at the second Workshop at Appendix 4.1. The architect's Code for Sustainable Homes checklist for Smith Lane (included at Appendix 4.2), noting Code 4 as 'difficult' (compared to Code 3 as 'easy' and Code 5 as 'expensive') is used to summarise the impact of the Code on the design of Smith Lane and relevant extracts related to Code 4 are listed in Table 4.1, showing the additional credits that need to be generated above those required for Code 3. These are considered below on the basis that the optimal generation of credits is needed to achieve a minimum calculated total of 68 points for Code 4 for Smith Lane within the dual constraints of a social housing grant regime and the contractor's financial model.

Table 4.1 Extract from the architect's checklist of Code 4 credits

Ref.	Element	Code 3 credits	Additional credits for Code 4
Ene 1	DER over TER – 44% improvement	5	+3
Ene 2	Building fabric (HLP[14])	1	1
Ene 7	Low carbon technologies	-	1
Mat 2	Key building elements	-	3
Mat 3	Finishing elements	-	1
Hea 1	Daylighting	1	1
Eco 1	Improvement of ecological value	2	2

Elements which have generated innovation within the design process are discussed in detail in Section 4.12 and noted as such within the text that follows. Otherwise, detail from the analysis is included below.

4.2.1 Ene 1 - DER over TER - 44% improvement

The aim of Ene 1 is to limit CO_2 emissions from the 'operation of a dwelling and its services' (DCLG, 200a:21). Ene 1 measures the percentage improvement in the CO_2 Dwelling Emission Rate[15] (DER) and Code 4 requires a mandatory 44% minimum improvement over Target Emission Rate (TER) as determined by 2006 Building Regulations, for which 8 credits are available, rising to 13 for an 89% reduction (DCLG, 2008c:40). The architect and contractor spent some time working through a range of possible options to meet the 44% target and these are discussed in Sections 4.12.1 and 4.12.2.

4.2.2 Ene 2 - Building fabric

The aim of Ene 2 is to limit the heat loss of the building envelope, promoting the efficient design of homes and the increase of levels of insulation and airtightness. A maximum of 2 credits are given for the Heat Loss Parameter measure, calculated from the external surface area,

[14] HLP – Heat Loss Parameters
[15] DER – 'the estimated CO_2 emissions in kg per m^2 arising from energy use for heating, hot water and lighting for the actual dwelling' (DCLG, 2008a:21).

construction insulation value and airtightness. A key part of the Smith Lane project was the negotiation between the architect and the contractor to generate a building envelope solution that would achieve an appropriate HLP measure for 1 credit. This process is identified as innovative and is discussed in detail in Section 4.12.1.

4.2.3 Ene 7 - Low carbon technologies

This element relates to the local generation of energy by, for example, photovoltaic panels and ground source heat pumps for individual homes. Credits are awarded for the resulting potential percentage reduction in CO_2 emissions (1 credit for a 10% reduction, 2 credits for a 15% reduction). Again, the use of low carbon technologies as a contribution to the reduction of CO_2 emissions in the design of the Smith Lane homes is identified as innovative and discussed in Section 4.12.2.

4.2.4 Synthesis of Ene 1, Ene 2 and Ene 7.

These three elements generate a possible 5 credits, representing half of the additional credits needed above Code 3 to achieve Code 4 with a minimum calculated 68 points. Although noted separately above, they also operate in conjunction with each other to achieve the mandatory minimum 44% CO_2 reduction target for Ene 1 to achieve a Code 4 certification. The design of Smith Lane's homes, by the architect and the contractor within the client's Design Guide and the HCA's requirements includes all three elements as a complex product and reflects a complex innovation process.

4.2.5 Mat 2 - Key building elements

Mat 2 encourages the specification of responsibly sourced building materials and credits are awarded, up to a maximum of 6, where 80% of assessed materials are responsibly sourced, using 'auditable third party

certification schemes' (DCLG, 2008a: 36) for the eight key building elements[16].

The impact of this element of the Code on the design of Smith Lane is limited, analysis showing that the architect preferred traditional rather than timber frame construction to achieve Mat 2 credits, with materials specified from the BRE Green Guide to Specification (2002). This choice was not assessed as innovative because the guide was in current use.

More generally, the contractor noted the impact of the 'chain of custody' for, for example, timber needing sustainability accreditation from a company who 'can monopolise a bit on the Code' and charge a premium which pushes up build costs.

4.2.6 Mat 3 - Finishing elements

Mat 3 is similar to Mat 2 for finishing elements[17], up to a maximum of 3 credits. Analysis for this Code element for Smith Lane showed that its impact for the design team was minimal, with the exception of the contractor, as the only member of the team whose role included the sourcing of finishing elements, noting the amount of time spent in defining a chain of custody for, for example, minor finishing elements such as a washing line as part of the Code accreditation process.

'...you can lose weeks trying to get things sorted, on top of our normal job – can you send me a specification of the washing line...you can get really bogged down in the details' (Contractor).

[16] Eight key elements – frame, ground floor, upper floors, roof, external walls, internal walls, foundation / substructure, staircase (DCLG, 2008a).

[17] Eight finishing elements – stairs, windows, external and internal doors, skirting, panelling, furniture, fascias, any other significant use (DCLG, 2008a).

4.2.7 Hea 1 - Daylighting

The aim of Hea 1 is to reduce the need for energy to light the home thereby improving 'quality of life ... through good daylighting'. Additionally, good daylighting and 'solar gain' works with thermal efficiency (Ene 2) to provide heat during winter. Credits are given up to a maximum of 3 when all main rooms (excluding bedrooms, corridors, bathroom and WC) achieve a minimum average daylight factor and a percentage of the 'working plane' for these rooms receives direct light from the sky (DCLG, 2008a: 49).

For the contractor's standard house design, there is a tension between the generation of credits to achieve the daylighting standards for Hea 1 and the 'housebuilders not putting enough windows in', expressed as the preference of purchasers for smaller windows.

'People don't want big windows, they just want enough light and to be able to see out, but to get the daylighting credit a percentage of light has to hit the middle of the room' (Contractor).

The architect notes a saving of 5 to 10% on heating costs with larger windows. However, for north-facing windows where there is minimal solar gain, windows need to be bigger to meet Hea 1:

'...in the Code, there are minimum lighting levels for rooms that face north and that's a conflict, it's a nonsense '(Architect).

Thus a three-way tension is expressed between the daylighting credits, the additional cost of larger windows and solar gain compromise for north-facing windows. Additionally, the HCA, in specifying a minimum Code 3 for housing developments in receipt of NAHP funding, requires windows that are large enough to meet Code 3's Hea 1 standards within their Housing Quality Indices (HQIs). Although this element is not mandatory, it generates an additional credit for Code 4, where others may have been

even more problematic. The resolution of this tension was not noted as innovative for the research analysis.

4.2.8 Eco 1 - Improvement of ecological value

Although listed by the architect as Eco 1 (defined as 'Ecological site value' and aimed at encouraging development on land with an inherently limited value to wildlife, using a range of criteria and generating a maximum of 1 credit) it is possible that this element is Eco 2 'Ecological enhancement' which aims to enhance the ecological value of the site with the advice of a 'suitably qualified ecologist' (DCLG, 2008a: 61) for a maximum 1 credit.

For Smith Lane, the impact of this element is the early contractual involvement of an ecologist to support this single credit, noted by the contractor as 'easy'. The architect's layout at Appendix 4.3 includes the planting locations of 195 trees and shrubs (and further layouts show tree and shrub species and their 4 alternative tree-staking details). Appendix 4.3 also shows the location of 4 log piles, 8 bat and 8 bird boxes in house gables and 2 reptile refuges (marked at XX Ⓑ B and R respectively).

4.2.9 The impact of the Code on the design of Smith Lane

The impact of the Code as the generation of additional credits to achieve Code 4, as summarised by the architect, addressed the detail of those Code criteria that were noted by case study participants and did not specifically involve an innovative response and referred to analysis for Research Question Two for those that provoked an innovative solution.

The following sections extend the analysis and discuss the general impact of designing to meet Code 4 across the sector evidenced by case study data at organisation and sector levels.

4.3 The impact of the Code on organisations

As the table at Appendix 4.1 shows for Project A, the relevance of the Code is different for each organisation taking part in the early stages of development projects, although the impact on the project is jointly absorbed. Impacts for individual organisations are identified from case study data and as there is no common unifying characteristic organisational response to the Code that can be identified, responses can usefully be synthesised in terms of organisations' role within Winch's CoPS model of innovation discussed in Chapter 2, Section 2.8.3 and summarised in Chapter 3, Figure 3.3 in the context of Project A's team.

4.3.1 Local Authority housing

Project A's local authority owns and manages its housing stock (not having transferred it to an LSVT or housing association) and the impact of the Code on the Local Authority housing team is expressed in terms of extending leverage on improving energy efficiency, through retrofit, of its own existing stock.

4.3.2 Housing association client

Project A's housing association client has responded to the Code by revising its design guide for new housing that includes options for achieving Code level 3 (as the standard required by the Homes and Communities Agency). The Code provides a lever for the client to re-assess its 'green credentials', taking marginally increased amounts of existing staff time but with no extraordinary or significant additional cost, or new staff posts. The target audience for any increased 'green' profile is primarily at a sector level and within the local and regional housing infrastructure, rather than current and potential residents.

4.3.3 Homes and Communities Agency

The Homes and Communities Agency incorporate the levels of the Code as progressive environmental standards for awarding grants within their three-year programmes, moving developments on from EcoHomes Very Good defined in the 2006 - 2008 programme to a minimum Code level 3 for 2008 - 2011. The National Affordable Housing Programme (NAHP) grant for Smith Lane was awarded from the 2008 - 2011 funding round. The client also successfully applied for additional grant for a Code 4 development, although there is no automatic grant award uplift for Code 4 homes within the 2008 - 2011 programme.

4.3.4 Local Authority planning team

The Local Authority planning team exerts a traction on the design of new homes via the county council's Core Spatial Strategy, adopted in June 2008 and covering four local planning authorities. Specifically, Policy 14 on energy efficiency and sustainable construction, sets out expectations for the Code where large developments of 200 or more homes need to meet a minimum of Code level 3 in order to achieve planning permission. For smaller schemes of 10 or more homes, the requirement is to show 'that at least 10% of the demand for energy will be met on-site and renewably' (County Council Core Spatial Strategy, 2008: 67), thus additional Code design requirements are not included for this volume of new housing.

4.3.5 County Council Highway Authority

The County Council Highway Authority (CCHA), located in the innovation superstructure, whilst aware of the Code, is not directly responsible for its implementation so the impact on this organisation is negligible. However, the role of this agency in the early stages of Smith Lane is significant in the context of the design of the access into and layout of the development and for the layout of the internal road as a loop rather than a cul-de-sac. This requirement is dictated by the number of homes off a single access

point in the context of emergency access. This defines the placement and orientation of homes in a limited scheme layout to optimise solar gain which has an impact on meeting the Energy and CO_2 emissions criterion of the Code and on the potential space available for additional external Code structures such as Ene 8 (Cycle storage), Wat 2 (Water butts) and Was 3 (Composting). Although county councils' Highways Authorities have an active input into the early stages of housing development projects, usually enacted through advisory meetings with the client, engineer and architect, to discuss details of road access for, for example, emergency and other non-resident vehicles (such as bin lorries and removal vans), this early aspect of the design process is not generally addressed in construction research or literature.

4.3.6 Architect

The impact of the Code on the architect for Project A is absorbed by professional experience and background in designing homes to meet EcoHomes standards, informed by a general interest in sustainability and its application in housing and supported by expertise as an EcoHomes and a Code assessor. For Smith Lane, the Code elements for Ene 8 (Cycle storage), Ene 9 (Home office) and Was 1 (Refuse storage for recycling) noted by the architect as having an impact on the scheme design, were included in the early design of the homes and gardens. The space these require have an impact on both cost and space within HCA grant levels and standards. However, the design of homes to meet the Code up to level 4, including solar and photovoltaic technologies and passive solar design, are within the capabilities of an architect without the need for additional knowledge and training.

4.3.7 Contractor

For the contractor, the impact of the Code is characterised as an external force or a push for additional work in, for example, establishing chains of provenance for materials where certified suppliers may not be the most

competitive which can increase the build costs. Additionally, the cost of additional management time in submitting detailed Code submissions to BRE has an impact. The Code is seen as a regulation that has to be quantified and its impact understood in terms of the cost of the easiest way to achieve the mid-level Codes 3 and 4. The business model for the contractor is to buy in expert consultancy as necessary, and consultants will feed in information that will filter through the relevant sections of the organisation.

4.3.8 Civil engineer

The engineer, working specifically on sustainable drainage plans within Code elements Sur 1 and Sur 2, generating a maximum 2 credits each, continues to apply civil engineering expertise and thus the Code does not present significant additional work or require new knowledge.

4.4 The impact of the Code on organisations - summary

Figure 4.1 captures the origin and impact of the Code on Project A within Winch's CoPS model of innovation, by overlaying Smith Lane's project team organisations on Winch's model and using arrows to show the direction and impact of the Code on these, as expressed in interview and second workshop data.

Figure 4.1 Impact of the Code at project level

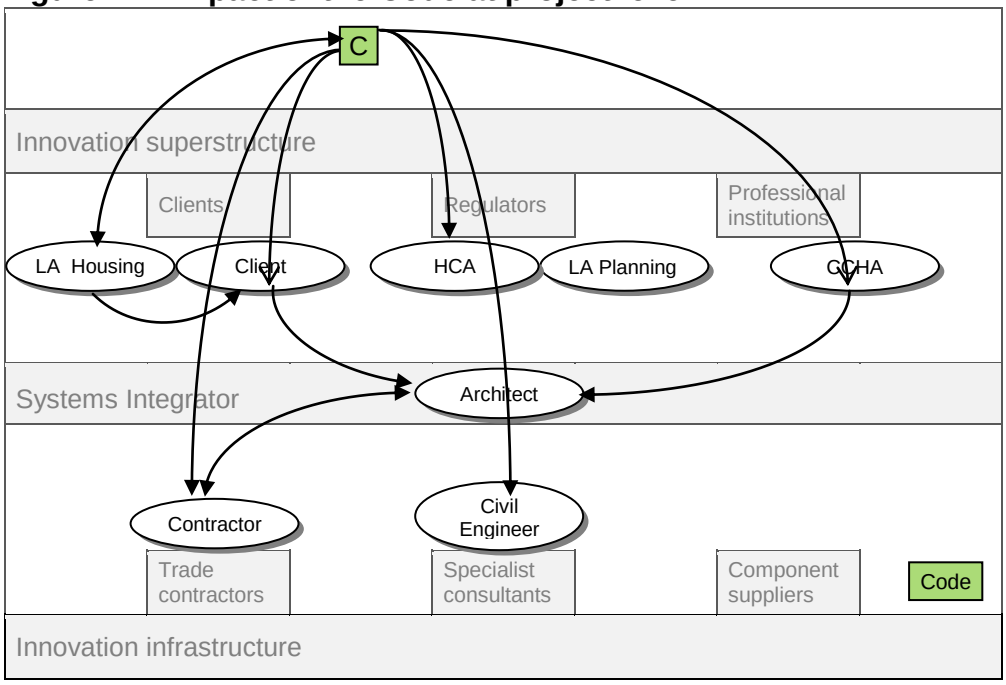


Figure 4.1 demonstrates that the impact of the Code is both non-linear and complex amongst Project A's organisations when integrated with Winch's CoPS model of construction innovation. Within the project, the architect, as the Systems Integrator, absorbs the indirect impact of the Code via the client, contractor and CCHA. Additionally, the Code has direct impacts on the innovation infrastructure organisations (the contractor and engineer), encouraging the demonstration of 'their capacity in sustainable housebuilding' (DCLG 2008a: 6). However, the impact of the Code on innovation superstructure organisations (LA Housing, the client, both directly and via the local authority and the HCA) is also significant at this early stage, to the extent that the boundaries between innovation superstructure and infrastructure in responding to the Code are seen to be hazy and smudged as the whole project team work together to generate innovative solutions in response to the Code.

As noted in Chapter Three, the original vision for Smith Lane was conceived by the Local Authority Housing Team, inspired by a

presentation by Wayne Hemingway[18]. However, the requirements across the project development team that this vision generates are multiple and non-negotiable, as reflected in Figure 4.1, and these will be replicated across all housing development projects meeting Code 4 from 2013 within the Code's introduction timeframe.

The following section generalises the analysis of the impact of the Code for Sustainable Homes on the case study project with a consideration of the sector.

4.5 The impact of the Code on the sector

As noted in the Introduction to Research Question One, this section uses Winch's innovation superstructure and infrastructure as a framework for considering the impact of the Code on the sector, because it provides a way of separating organisations which apply the Code from those which work to meet its requirements.

Organisations within the innovation superstructure support the use of the Code by including a requirement for it in relevant local authority policies and in regional county council corporate strategy (as noted for Project A in Section 4.2.4.4). At the time of the research project, meeting the Code at level 3 was mandatory only for housing developments in receipt of Homes and Communities Agency grant funding, and voluntary for private developments.

Housing contractors, within the innovation infrastructure, regard the Code as a regulatory force which pushes them to re-visit and modify standard house types to accommodate Code 4 and subsequently Codes 5 and 6 sustainability standards at a faster rate than they may otherwise have done. Standard house type models will have bigger windows, more

[18] Wayne Hemingway – acclaimed designer of contemporary items, including affordable, sustainable social housing. http://www.hemingwaydesign.co.uk/html/projects.htm.

insulation and south facing orientation for solar gain, changing both their appearance and the way they are occupied. The business risk for the innovation infrastructure is that, in the short term, buyers may not like, and therefore may not buy, the newly-designed standard homes that meet Code requirements and are financially viable for the contractor. Although Code 3 has been successfully accommodated by the sector, Code 4 is viewed as stretching the sustainability target, and ways of meeting Codes 5 and 6 are described as unknown and untestable for volume housing.

4.6 The impact of the Code - summary

Analysis of Project A research data shows that the requirement to develop Code 4 housing has an impact at all levels of the CoPS innovation model. Designing to Code 4, in particular for the architect as System Integrator and the organisations (contractor and engineer) at the innovation infrastructure level, is primarily one of negotiation around existing techniques and technologies to define the most cost effective way of achieving specified CO_2 emission levels within the social housing grant available that meets the contractor's financial and business models. For organisations developing within a social housing development framework, meeting the Code is a funding requirement, and although for Project A the local authority vision for Smith Lane was unique at the time of the case study, all new housing will need to meet at least the CO_2 reduction targets embedded within Building Regulations from 2013.

The key finding arising from the Research Question One on the impact of the Code on the design is expressed as follows:

Finding One: The impact of the Code for Sustainable Homes at the design stage of social housing development projects is one of negotiation around existing techniques and technologies to define the most cost effective way of achieving CO_2 emission targets within the client's social housing grant and the contractor's financial model.

Finding Two: The physical limitations of the site and the requirements of the road layout may impact on the space available for the number of homes defined for the development and for their orientation and placement to optimise solar gain and to accommodate external Code features such as water butts, cycle storage and composting.

A significant impact of the Code is expressed as a cost by case study interviewees and this is considered next at both sector and end-user levels, where the additional costs for the client of providing the features of Code 4 homes, and for the client of maintaining these features, is recognised as a cost-saving benefit for residents as end-users in case study data.

4.7 The costs of the Code

Analysis of Project A's data illuminated the practical context of meeting the requirements of the Code, specifically the reduction of CO_2 emissions, for the innovation superstructure and infrastructure. The additional costs of techniques and technologies for achieving CO_2 reductions are reflected in a constant thread throughout the semi-structured interview transcripts. The thread links the architect and the contractor, as the organisations specifying and costing the details within the social housing grant regime, to the Homes and Communities Agency and the housing association client.

> *'The challenge is on cost grounds, and the more expensive the scheme, the less units you can deliver – so it's not the technology or the skills or anything like that – it's the cost involved in doing it' (Client)*

> *'I don't want to give away what our profits are…we have economic performance indicators where we have to take a minimum value per plot profit...this site, being affordable, the level of profit that we're looking to take is considerably less than a private housing scheme' (Contractor)*

It is generally accepted by innovation superstructure and infrastructure project partners that there are additional costs in the design and build of

Code homes compared to those that meet Building Regulations. The extra cost of Code 3 ranges from an estimated £2,500 (HCA) to £6,000 extra per plot (Contractor) using a standard house type with an additional Code 3 package of a solar panel system and increased floor, wall, ceiling and roof insulation. The costs of implementing Code 4 range from an estimated maximum of £7,000 (HCA) to £10,000 (Architect and Contractor), where the contractor uses a standard house type with an additional Code 3 package and a further renewable such as an air source heat pump.

4.7.1 The costs of the Code for the innovation superstructure

The costs of building to Code 4 are borne by the client in a contractual relationship with the building contractor. The original NAHP grant funding for Smith Lane allocated by the HCA to the client in April 2008, is summarised in Table 4.2 (HCA, 2008). Ten further homes within the initial plan, not grant funded, were for 'open market' sale.

Table 4.2 NAHP grant funding for Smith Lane

	Units	Total £'000	Ave. grant per unit £
Rent	20	1,300	65,000
LCHO	23	621	27,000
Total	43	1,921	44,675

However, this allocation was withdrawn (as described in Chapter Three, Section 3.11) and a DCLG press release in December 2009 (after the data collection phase of the case study) noted, in respect of Smith Lane, '£3,078,770 will support a development of 51 affordable homes (37 for social rent and 14 for affordable sale) to be built to Code for Sustainable Homes level 4, which meets a need for mixed tenure development of family housing and bungalows. The Borough Council are providing this

disused allotment site at nominal value and are strongly supportive of the development since it will help meet affordable housing demand outside of the town centre' (County Observatory, 2009).

This equates to an average grant allocation per unit of £60,370, in contrast to the case study participants who expressed the cost of achieving Code 4 housing as an addition to a normal build. It is therefore not possible, from available case study data, to identify the cost of building a Code 4 home at Smith Lane.

Applications for grant funding are linked to the costs of development, so that the higher costs associated with Code 4 for which the housing association can apply may be less attractive to the Homes and Communities Agency which has both a limited amount of regional grant funding available and an annual volume of developed homes to be met. This potentially prompts a notion that grant funding may be awarded for volume housing rather than for higher Code levels.

'...because what we ask for in terms of grant depends upon the cost to us in developing, so if it's going to cost us more to develop, we're going to ask for higher grant. Now if my [colleague] decides "I'm not going to bother with the Code" and develop cheaply, they can in turn ask for lower grant to deliver the same housing units, so the Corporation is likely to give them the grant, as opposed to giving it to us' (Client).

Additional costs for the client are implicit in ongoing maintenance and repair of the range of renewable technologies with contractors who have the appropriate skill base. The level of uncertainty for the client is significant in terms of cyclical maintenance planning. For example,

'a solar panel costing £3,000 may cost £1,000 to replace in one year because technology has evolved, or £3,000 to repair if it goes wrong' (Contractor).

Although there are no direct costs in meeting Code 4 for the local authority housing team, there is a recognition that private sector completions may be reduced because of additional costs and longer construction timescales, thus placing a potential burden on the housing register and the increased cost of temporary accommodation.

4.7.2 The costs of the Code for the Systems Integrator - architect

At this early stage of the design process, the architect takes the role of the Systems Integrator as a link between the innovation superstructure and infrastructure as noted in Chapter Three, Section 3.10. For the architect in Project A, the cost of additional professional time to design to Code 4 is absorbed in the fee paid by the client, within which the architect's profit margin goes down accordingly.

4.7.3 The costs of the Code for the innovation infrastructure

For the contractor, the Smith Lane project represented an opportunity to assess the cost of building to Code 4. There is a recognition that the cost of meeting Code 4 is 'quite a step change' as a forerunner to Codes 5 and 6, where costs are unknown and likely to be high.

> *'...if we have a standard house with a solar panel for Code 3, to get to Code 4 we can add an air source heat pump...it's different when you go above Code 4 – you get into silly territory' (Contractor).*

The challenge for Code 4, and then Codes 5 and 6, for the sector is the additional cost rather than the technology or the skills. Potential technologies for Smith Lane include combinations of photovoltaic panels with ground or air source heat pumps. Photovoltaic[19] technology is expensive; for example a neighbouring development of 33 flats included

[19] Photovoltaic (PV) technology ('solar panels') captures the energy of the sun and converts it to electricity using PV cells made of semi-conducting material, usually silicon. When light shines on the cell, an electrical field is created across its layers ((www.energysavingtrust.org.uk).

photovoltaic panels costing £10,000 to provide 40% of electricity for communal heating.

> *'...the mandatory challenge to achieve CO_2 reduction is much more stringent, and you have to find more innovative ways of constructing to achieve those reductions' (Client).*

4.7.4 End user costs

The costs for the end user are expressed in terms of potential savings on heating and lighting bills as a result of their occupation of Code 4 homes. The allocation of social housing is based on need rather than a preference for a particular home in the case study local area authority, so potential residents do not have the option to actively select a Code home (with the possible exception of Choice Based Lettings systems used by some registered landlords.[20]) Additionally, there is a feeling expressed by both the client and the contractor that occupants may not recognise or appreciate the benefits of 'Code' homes, where Code is used as a description. This is seen as jargon which is potentially meaningless, and a summary of headline features in terms of cost savings per annum may be more relevant. Once housed, residents will benefit from lower bills which will vary according to lifestyle and knowledge. Wider benefits for social housing end users are also recognised in terms of the quality of the internal environment's impact on improving health and well-being, which, for the social landlord may contribute to longer tenancies in more sustainable communities, and fewer arrears both as a result of increased satisfaction with homes, and a greater capacity to pay. For owner-occupiers, the concern of the developer was expressed as the loss of cost savings in repairs.

[20] 'Choice based lettings (CBL) system ... prospective tenants apply for available vacancies that are advertised, set up in order to give people more choice about where they live' (NHF, 2010:28).

4.8 The costs of the Code - summary

The costs of Code 4 are predominantly associated with achieving TER reductions of 44%, recognising that current technologies may be combined to achieve the CO_2 reductions of Codes 5 and 6 where cost is estimated to be high. Grant funding from the HCA is based on achieving a minimum Code level 3 and defines the financial model within which the client, architect and developer assess the optimum combination of building techniques, technologies and cost. There is an awareness that costs and ongoing maintenance implications are unknown for the early housing design and development stages, however knowledge to inform models will emerge over time based on accumulated experience. Explanations of Code housing, examples of cost savings and increased information on and help with lifestyle choices can enable social housing residents to appreciate sustainable homes.

In focussing on the Smith Lane project, the semi-structured interview format of data collection acted as a conduit for interviewees to talk about the Code as a regulation in more general terms. This provides a valuable context in which the Code is enacted, and is explored next.

4.9 Other regulation in Project A's given environment

The Code is expressed as just one of a network of regulations and standards that form a framework around the early stages of a housing project and their inclusion in the analysis is justified to confirm the complexity and volume of regulation as examples of the characterisation of the construction sector as 'the most regulated of all industries' (Morton & Ross 2008:202). Analysis of transcripts for Project A generated references to thirty six regulations, guidance and external requirements, in addition to the Code for Sustainable Homes. The value of this additional data is optimised to add a further dimension to the research, reflecting the complex nature of the regulatory framework of early housing development projects and the day-to-day business environment for the organisations

involved. However, it should be noted that semi-structured questions did not include an invitation to describe or list regulation in addition to the Code for Sustainable Homes, and that other regulation, not described, may also exist.

Table 4.3 lists the thirty six additional regulations, standards, design guides and other constraining external requirements (using 'regulation' as a generic term) in detail and notes their relevance to Project A and their origin and impact on Project A's participants. The list is ordered by the CoPS model role of the project participants as reflected in the standard figure used throughout the thesis, and then by the impact on Project A, so that external requirements that are directly relevant to the design of Smith Lane appear before those that are not relevant. The list is not a numerically accurate summary of regulatory drivers. It captures the range and volume of external requirements that housing development project teams need to address, expressed during semi-structured interviews. Some regulations are duplicated, and their specific relevance for the participant is expressed. Some descriptions of the regulations are expressed in the words of the project participants (in inverted commas), to reflect their perspectives, and any descriptive anomalies have not been corrected. The aim for Table 4.3 is to capture the richness and complexity of case study data on the regulatory given environment, which includes the Code for Sustainable Homes, expressed by project participants.

Table 4.3 List of additional regulations noted by Project A participants

Ref	Participant	Regulation / external requirement	Detail from transcript	Specific impact on Project A	Direction of general and specific impact (for Figure 4.2)	
					Origin of...	Impact on...
1	LA Housing	Building for Life	'We wanted to tick a lot of boxes and try and achieve all of it'.	Has an impact on the design of the homes and layout of the site.	LA Housing	Client Architect
2	LA Housing	SPD - Supplementary Planning Document	The SPD is referred to in the regional design guide as part of the 20-year urban extension framework in which use of the Code is promoted rather than forced.	Code 4 required for Smith Lane	LA Housing	Architect
3	LA Housing	Planning Policy Document	Influences sustainability for new private developments.	Not relevant as Smith Lane is publicly-funded.	External	LA Planning
4	Client	HCA HQIs	HCA performance indicators for scheme design. The minimum standard is Code 3	Exceeding the Code 3 minimum has a cost implication for the client 'but it is worth it'.	HCA	Client Architect
5	Client	'The newt report'	A reptile survey is a requirement of the Planning process	'Fortunately there haven't been any newts or reptiles or anything like that to cause us headaches!'	LA Planning	Client
6	HCA	Building for Life	Included as one of the HCA's design criteria guides	Smith Lane achieves a score of 85	HCA	Client Architect
7	HCA	HCA Design Guide	Specifies standards for design of new homes in receipt of HCA funding.	Smith Lane, at Code 4, exceeds progressive Code 3 minimum standard.	HCA	Client Architect
8	HCA	HCA HQIs	Defines minimum standards for liveability, including e.g. room size and layout so that furniture items will fit in.	The size of homes defined by the HCA and the number of homes defined by the LA may have been in tension on the land available at Smith Lane.	HCA	Client Architect
9	HCA	Planning permission	The HCA checks that funded schemes meet their planning permission conditions	Applicable to Smith Lane	HCA	Client
10	HCA	Regional Assembly reporting	Monthly reports on funding and delivery of housing.	N/A (though Smith Lane is included in HCA reporting).	External	HCA
11	HCA	Deliverability	Government-specified targets on	N/A (though Smith Lane	External	HCA

Ref	Participant	Regulation / external requirement	Detail from transcript	Specific impact on Project A	Direction of general and specific impact (for Figure 4.2)	
					Origin of...	Impact on...
		targets	deliverability of HCA- funded housing by LA area.	contributes to HCA's LA targets).		
12	HCA	Funding cycle	DCLG sets 3-year funding and housing programme targets for HCA regions	N/A (though potential re-negotiation of Smith Lane funding gave HCA capacity to fund alternative schemes).	External	HCA
13	LA Planning	Section 106	Contribution made to Local Authority to offset impact of development.	An S106 agreement was defined for Smith Lane.	LA Planning	Client
14	LA Planning	Planning conditions	Conditions can relate to e.g. timescale, appearance, landscaping and access.	Planning conditions were included in Smith Lane's planning permission.	LA Planning	Client
15	LA Planning	Core Spatial Strategy	Includes definition of timescales and volume of new housing supply.	Smith Lane feeds into this.	LA	LA Planning
16	LA Planning	Sustainable Community Strategy	LA strategy that includes requirement to gather and report on resident satisfaction with homes and neighbourhoods	N/A at this early stage, though residents will be included post-development.	LA	LA Planning
17	LA Planning	Town and Country Planning Act	Reflected in LA's timescales for the planning process	Timescale and process relevant to the client's application for Smith Lane.	National	LA Planning
18	CCHA	CC Place and Movement Guide	Recently published and adopted county guide, complying with Manual for Streets. Includes a specification for parking standards.	Principles proposed within Smith Lane site layout plans.	CC HA	Architect Engineer
19	CCHA	Design Bulletin 32	Established national guidance of general criteria for road design. Principles absorbed into Manual for Streets and CC's Place and Movement Guide.	Smith Lane generates opportunity to apply DB32 framework in conjunction with CC's new Place and Movement Guide.	CC HA	Architect Engineer
20	CCHA	Home Zone	Home Zone is relevant to	A Home Zone style was adapted	CC HA	Architect

Ref	Participant	Regulation / external requirement	Detail from transcript	Specific impact on Project A	Direction of general and specific impact (for Figure 4.2)	
					Origin of...	Impact on...
			renewal of existing areas, giving priority to pedestrians in shared roads. It has a legal significance.	by the architect for the Smith Lane site layout.		
21	CCHA	Circular 805	Obliges the CCHA to respond, as a consultee in the planning system, within 21 days of sufficient information being provided by applicants.	Relevant to Smith Lane's application for planning permission.	External	CCHA
22	CCHA	Public utilities legislation	Specifically, unadopted roads present a high risk to the CC in terms of e.g. emergency work to water supplies.	Ownership of the access lane leading to the Smith Lane site was a key issue for Project A.	External	CCHA
23	Architect	Building for Life	Environmental award for new housing, with three levels. The highest, gold, requires a scheme to have 'some character'.	Achieving gold was a further condition for the LA's land gift.	LA Housing	Client Architect
24	Architect	Secure By Design	Police standard for housing scheme design to reduce crime.	Smith Lane road cannot be used as a 'rat run'.	LA Housing	Client Architect
25	Architect	Home Zone	National neighbourhood renewal design standard for roads to be shareable by all users.	Home Zone principles specified for Smith Lane by client and LA Housing.	LA Housing Client	Architect
26	Architect	HCA HQIs	HCA's schedule of facilities to be included in new housing design.	Schedule noted and incorporated in Smith Lane design.	HCA	Client Architect
27	Architect	Highways requirements	Specifically, the county council's highway regulation defines the length and style of road in relation to the number of houses.	Too many houses required by LA for Smith Lane to be designed as a cul-de-sac	CCHA	Architect
28	Architect	Building Regulations	National minimum standard for design and construction. Noted by the architect as the proper vehicle for specifying the Code's nine sustainability criteria.	Applicable to Smith Lane.	External	Architect Contractor

Ref	Participant	Regulation / external requirement	Detail from transcript	Specific impact on Project A	Direction of general and specific impact (for Figure 4.2)	
					Origin of...	Impact on...
29	Architect	Policy Planning Guidance 24	PPG24 defines a national standard for acceptable levels of noise and vibration.		External	Architect
30	Contractor	'Environmental and sustainability hoops'	These are construction targets related to not increasing volume of water run-off, and cleaning up pre-existing site contamination, defined in a ground investigation report as part of the planning process.	Smith Lane's planning application included a water attenuation system and a contamination remediation strategy.	External	Engineer Contractor
31	Contractor	D4 policy.	D4 is in use in a neighbouring LA, giving developers a choice of EcoHomes Excellent and a carbon offset contribution, or Code 3 without a contribution.	Not applicable in Smith Lane's LA.	N/A	N/A
32	Engineer	County Council Highway requirements	Planning applications need to include a traffic assessment and a travel plan.	Completed by independent organisations for Smith Lane's application.	LA Planning	Engineer Client
33	Engineer	Policy Planning Statement 25	PPS25 requires a flood assessment to be carried out for the Environment Agency.	Assessment included as part of the planning process.	LA Planning	Engineer Client
34	Engineer	County Council Highway road design requirements	Defines road design standards.	Included in Smith Lane's engineering plans and planning application.	CCHA	Engineer
35	Engineer	Manual for Streets	A new national guide that supersedes Design Bulletin 32 for residential roads.	Smith Lane was the county's first development designed to this standard, where the engineer and Highways worked to implement new ideas without compromising DB32, to provide a safe route into around and out of the site.	CCHA	Engineer

Ref	Participant	Regulation / external requirement	Detail from transcript	Specific impact on Project A	Direction of general and specific impact (for Figure 4.2)	
					Origin of...	Impact on...
36	Engineer	Environment Agency standards	Defines performance for site drainage.	Included in Smith Lane's engineering plans and planning application.	External	Engineer Client

The main conclusion arising from Table 4.3 is evidence of the breadth and volume of regulatory requirements within the given environment for Project A as an early housing development project. Each of the project partners noted a range of regulatory requirements and these should be considered as the context for the Code for Sustainable Homes. Having listed these, the following text and tables extract details to show the frequency, volume and impact of the regulations noted.

Table 4.4 summarises the frequency with which regulations directly associated with the design of Smith Lane were mentioned by interviewees.

Table 4.4 Frequency of citation of additional regulations

CCHA requirements	3
Building for Life	3
Housing Quality Indicators	3
Home Zone	2
Manual for Streets	1
Others	All 1

These first five regulations are the principal design guides within the given environment, defining the details for the homes and layout of the Smith Lane site and are relevant for organisations across the project team, in addition to the Code for Sustainable Homes. Analysis of data showed that their impact on the design is significant.

Table 4.5 summarises the number of regulations noted by each of Project A's participants, sorted by Winch's innovation structure for Complex Product Systems industries.

Table 4.5 Number of additional regulations noted, by CoPS project role (Winch, 1998)

Innovation superstructure		
Client	LA Housing	3
Client	Client	2
Regulator	HCA	7
Regulator	CCHA	5
Regulator	LA Planning	5
Total		22
Systems Integrator		
	Architect	7
Innovation infrastructure		
Trade contractor	Contractor	2
Specialist consultant	Civil Engineer	5
Total		7

This suggests that the innovation superstructure within the CoPS model recognises far more regulations that the Systems Integrator and the innovation infrastructure organisations. Further analysis will show that these organisations, as local or regional representatives of national agencies, operate within a series of regulatory requirements in their own given environments. Table 4.6 refines the information on additional regulation in the given environment noted by project participants by identifying the volume of regulatory origins (a requirement of other organisations) and impacts (required by other organisations) by CoPS framework role.

Table 4.6 Origin and primary & secondary impacts of additional regulations

CoPS framework	Participant	Origin	Primary impact	Second -ary impact
Superstructure				
Client	LA Housing	5	-	
Client	Client	-	12	3
Regulator	HCA	6	3	
Regulator	CCHA	6	2	
Regulator	LA Planning	5	4	
Systems Integrator	Architect	-	8	9
Infrastructure				
Trade contractor	Contractor	-	-	2
Specialist consultant	Civil Engineer	-	6	2
External to project context		11		

Table 4.6 shows that, at this stage of the development process, regulation is both generated by and impacts on the organisations within the innovation superstructure. In contrast, the innovation infrastructure organisations bear the impact of many, though not all of the superstructure regulations. In particular, the client is seen to generate no regulation and to absorb a majority, and the architect, as the System Integrator, absorbs a significant proportion of these regulations within the project landscape, many from the client.

Tables 4.3, 4.4, 4.5 and 4.6 capture the breadth, volume, origin and impact of the regulatory framework of the early stages of a housing design and development project, as described by participants in their own words. For the Research Question, they provide a powerful context within which the Code for Sustainable Homes generates its own impact on the early stage of Smith Lane's design. The 36 references in Table 4.3 are transferred to Figure 4.2 as an image of the volume and impact of the requirements in the project team's given environments for Project A as a

representative Code 4 housing design project, mapped onto Winch's model of innovation of complex product systems. Figure 4.2 illustrates the intricate network of regulatory origins and impacts noted by the case study project participants, showing that the Code does not exist in isolation, and that the design of a 'Code 4' home does not reflect the complex and multiple additional and equally important design requirements.

Figure 4.2 Project A's given environment

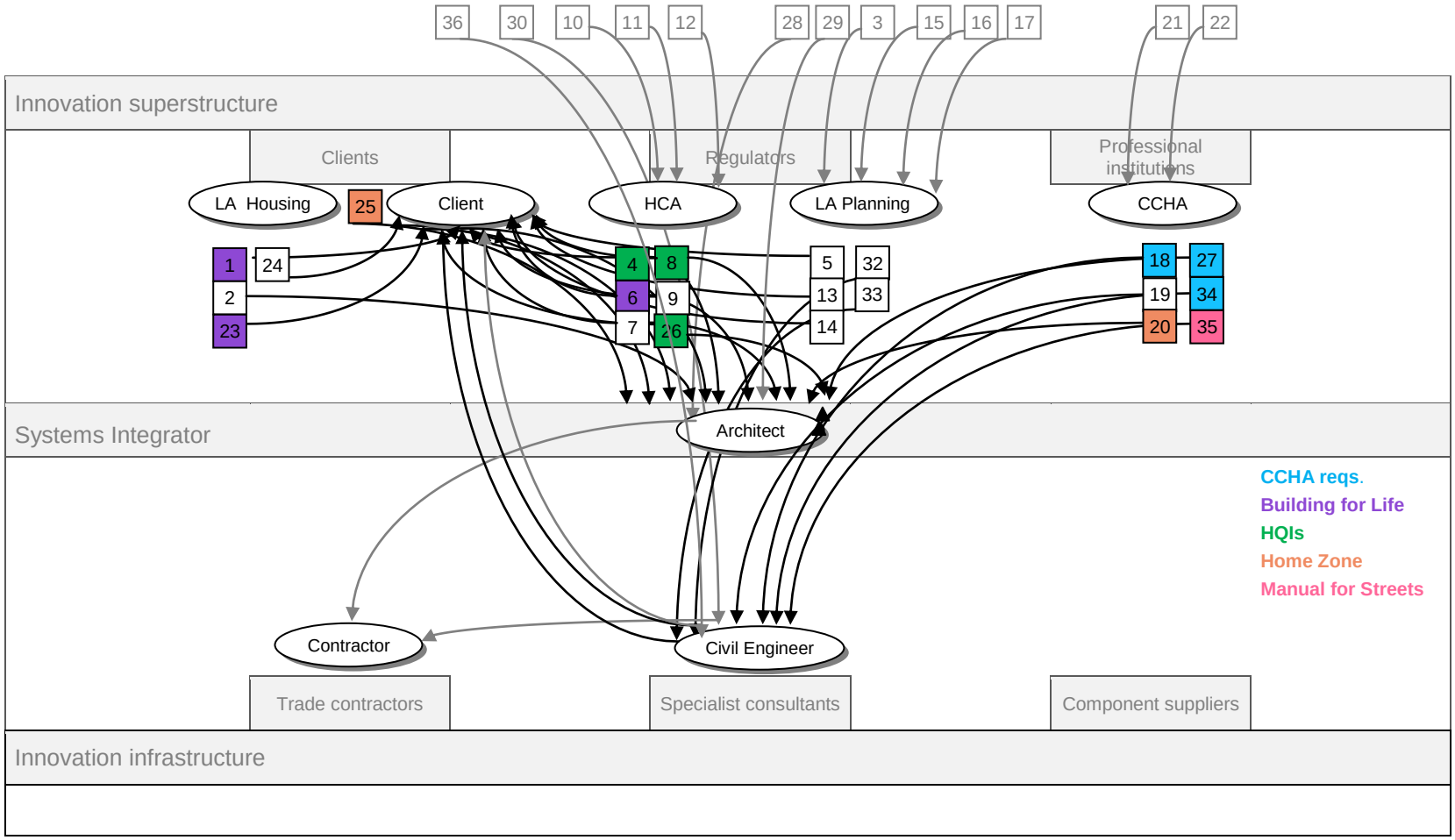


Figure 4.2 provides an image of the regulations noted in Table 4.3 and demonstrates that the regulatory background of the given environment for early housing development projects is both intricate and multi-directional. However, Figure 4.2 is based on analysis of interview transcripts and is therefore not necessarily a comprehensive list of relevant regulation.

Given this limitation, four points arising from preceding analysis and Figure 4.2 are noted. First, the five organisations within the innovation superstructure cite most regulations, in terms of either origin (a requirement of other organisations) or impact (required by other organisations). Secondly, regulatory 'traffic' is dense from the regulators (the regional HCA and the local authority housing team) to the client. This relationship reflects the nature of the funding regime for new social housing and the associated conditions of design, value and delivery required from the housing development project. Thirdly, the architect absorbs a range of regulation from across the innovation superstructure, particularly from the regulators either directly or via the client. Finally, the role of the civil engineer in designing the access and road layout is clearly reflected in the responses to the requirements of the CCHA team.

In the context of the relationship of innovation and regulation, these points suggest the following two conclusions. First, the patterns of regulatory flow and response confirm that the innovation superstructure drives innovation in response to regulatory requirements. Secondly, organisations within the innovation infrastructure respond to the requirement for innovation within the network of new and existing regulation as part of a contractual arrangement for fees.

However, in the context of the case study project, representatives from the innovation superstructure and infrastructure worked together in the development project's interaction environment to generate innovation to address the premise of Project A as an exemplar housing scheme meeting

the Code for Sustainable Homes level 4 as a condition of the land gift to the client, and Building for Life as defined by Homes and Communities Agency's grant conditions of design criteria and financial restrictions on new projects.

4.9.1 Additional design requirements generated by regulation

The primary focus for the research is the implications for innovation in the social housing development sector arising from the introduction of the Code for Sustainable Homes, and this remains the central focus of the present analysis. However, four additional design requirements for Smith Lane, defined by organisations within the innovation superstructure of Winch's model (2007) were expressed by case study interviewees. These were Manual for Streets, Home Zone, Building for Life and the Homes and Communities Agency's Housing Quality Indicators (HQIs).

Home Zone and Manual for Streets are relevant for the layout of the development site, and the HQIs consider the development as a whole, of which Building for Life is one of the key criteria. Collectively, these have a significant impact on the inception and early design stages of Smith Lane in conjunction with the Code for Sustainable Homes and as such their function and impact are considered in detail below.

4.9.1.1 Manual for Streets

The Manual for Streets (Department for Transport, 2007) was developed in response to a recognition that design guidance for streets, defined by the Department for the Environment's Design Bulletin 32 (1977, revised in 1992) and Places, Streets and Movement guide (1998), was 'standardised, prescriptive [and] risk-averse', and 'stifled innovation, leading to poor quality design of residential development' (Young, 2008:73) in which the main aim of street design was to facilitate movement of traffic. Biddulph (2008) notes that the Manual uses a concept of 'risk' defined by Adams (1995) where the responsibility for risk should be with

the drivers and pedestrians in a complex environment, rather than with engineers who ‘design out’ risk and therefore complexity. This is regarded as a ‘radical departure’ from previous advice (Biddulph, 2008, noting Castell, 2008) which had promoted car dominance and ‘[inhibited] innovative and safe solutions’ (Biddulph, 2008: 122). This, notes Young (2008), is the proper function of a highway, in contrast to a street which forms an integral part of ‘place’ in a relationship with buildings and public spaces. Notions of ‘place’ and ‘place-making’ are central concepts for the design of the built environment. There is no single definition of the term 'placemaking', however ‘creating somewhere with a distinct identity’ (Cowan, 2005) is used to summarise its elements.

A street should function as a shared, non-segregated space for all it users, with design for pedestrians, cyclists and public transport users as primary considerations, followed by service vehicles and other vehicles (Davis & Huxford, 2007).

Smith Lane’s County Council Highway Authority was the first county council to adopt the Manual for Streets as part of its Place and Movement Guide (Northamptonshire County Council, December 2008) for new developments, replacing its earlier Design Guide for Residential Roads. The new Guide gives priority to pedestrians and cyclists by using the environment to influence driving behaviours in sustainable developments that work for all users. The benefits of collaborative design and decision-making are emphasised in the creation of layouts for developments that generate a positive sense of place (Young, 2008), in contrast to the ‘set criteria’ of earlier guides with an implicit tick box approach, leading to

‘potentially ... dull, boring, repetitive layouts’ (CCHA).

The Smith Lane project team was the first in the county to apply the principles of the County Council’s new Place and Movement Guide, using

a hybrid approach between the earlier Design Guide for Residential Roads which reflected the precedence of vehicles, and the place-making concept of Manual for Streets. This early use of the County Council's guide with its incorporation of Manual for Streets and its 'new approach' (Department for Transport, 2007:2) had considerable implications for the concept and design of the road into and around the Smith Lane site, generating innovative approaches to the overall layout, the inclusion of legible[21] space for pedestrians and the detailed engineering of sight lines for vehicles.

For this research, the Manual for Streets provides a significant secondary example of a project team working to generate innovative solutions to a new regulation, and the evidence of innovation in response to the Place and Movement Guide in the data collected can be used to support the analysis of innovation in response to the Code for Sustainable Homes.

4.9.1.2 Home Zone

Home Zone[22] represents the most comprehensive solution on the spectrum of the creation of shared space, with mid-range options including traffic calming, planting and public art to create 'place'. The Home Zone concept originated in the 1970s in the Netherlands as a way of balancing street use between vehicles, pedestrians and cyclists by altering an area's streets to force motorists to drive more carefully. In the UK its primary driver was the creation of safe playing spaces for children close to their homes through environmental change rather than signposting in traditional streets. Various schemes applied the principles from the 1970s as part of urban renewal projects where the concept of shared road surface was pioneered, characterised by an absence of the kerbs and gutters of conventional designs. This generated difficulties for local authorities in defining legal liability for accidents occurring as a result of road users

[21] 'Legibility' is an urban design term that describes the understanding of a road layout by its users, for example pedestrians knowing they need to use a defined footpath.
[22] http://www.homezones.org.uk

(both on foot and in vehicles) being unclear about priority. The Transport Act 2000 contained a legal definition of shared space for roads that had previously been dedicated as highways primarily for traffic use, giving all road users an equal legal status. The Department for Transport's Home Zone challenge (2002 – 2005) funded the creation of 59 schemes to provide case studies to inform wider application (Biddulph, 2008). The resulting design guidance is minimal and therefore performance-based in terms of regulation, defining a range of issues to be taken into account by 'the informed but creative designer and engineer' (Biddulph, 2008: 124).

Biddulph notes that ongoing maintenance of Home Zone areas is potentially an issue for Highway Authorities, due to the more complex nature of surfaces and pavings (compared to traditional roads and pavements), and that more conventional designs may attract quicker planning decisions. For private housing developments, the commercial value of Manual for Streets and the more extreme Home Zone principles needs to be quantified, and the risk may be (as for homes built to new and radical standards) that the market prefers a 'relatively conservative and, for many, a very bland product' (Biddulph, 2008: 127) such that scope for innovation in street design may be diluted or stifled. Although Biddulph notes a need for national research to evaluate the new approaches to street design in newbuild schemes, there is no evidence that this is emerging or, more specifically for this research, any published work that considers the role and innovation in the design of such schemes.

For Smith Lane, a Home Zone approach was adopted on the advice of the county council's Highway Authority team leader, on the basis that Home Zone was appropriate for lightly trafficked streets, defined as less than 100 vehicles an hour in peak travel times. This may be reasonable for a development of 51 homes, however Smith Lane's looped road means that the 'lightly trafficked' definition was not appropriate. In addition, although Home Zone defines shared space from boundary to boundary, a legible

'safe zone' was created for pedestrians on one side of the street as a way of defining where vehicles could not go, either driving or parking. A varied roadway width was created to accommodate on-street parking, in contrast to a Home Zone, place making option of parking behind homes in courtyards.

Having outlined the nature and purpose of the Manual for Streets and Home Zone as the two primary guides for Smith Lane in the design and purpose of the street layout, and noted the impact of Manual for Streets on innovation within the project team and its potential contribution to this research, the two additional housing design requirements are considered.

4.9.1.3 Homes and Communities Agency Housing Quality Indicators

The Housing Quality Indicators (HQIs) were developed as an explicit measure of quality to balance the emergence of cost as the primary measure of social housing, where Housing Corporation grants included a cost criterion and implied a 'bed spaces per pound' approach, leading to housing with small rooms and estates with poor facilities (Wheeler, 2003:206). During the early 1990s a realisation emerged that cost, statutory regulations and minimum standards did not generate quality or value for money in new social housing, either for social landlords or for their tenants, and a series of HQIs were developed to address this concern, recognising that the value of homes lies partly in their successful contribution to sustainable communities.

Wheeler (2003) notes that any quality assessment tool needs to be accurate (with a capacity to combine both objective and subjective elements of value) and practical (in terms of useability and cost). The HQI system considers the location, design and performance of a housing scheme, marked against ten Quality Indicators including external elements of location, movement and visual impact, and internal elements of size, layout and noise. The sustainability agenda, and specifically the

introduction of EcoHomes, is foreshadowed with a dedicated Quality Indicator on energy, green and sustainability issues. Each Indicator has 20 to 30 questions, generating an overall score and scheme profile. Wheeler notes 'there is no single way to achieve a good score, just as there is no single way to achieve quality' (2008: 208) describing the Housing Quality Indicators as an example of a performance-based regulation.

The development of the HCA's Design and Quality Standards, which incorporate the formal assessment and measurement of the Housing Quality Indicators, emerged as a response to the cost-based context noted by Wheeler. The Design and Quality Standards replaced the earlier Scheme Development Standards at the start of the HCA's 2008 - 2011 NAHP funding round and so were relatively new during the Smith Lane research case study, though not specifically identified as such by case study participants.

4.9.1.4 Building for Life

This is the 'national standard for well-designed homes and neighbourhoods'[23] applicable to new housing developments. It was founded in 2001, overseen by CABE (Commission for Architecture and the Built Environment) and the HBF (Home Builders Federation) partnership, and was in use at the time of Project A. The Building for Life standard assesses twenty criteria based on national planning policy guidance and urban and housing design principles (including the Code for Sustainable Homes) across four categories: environment and community; character; streets, parking and pedestrianisation; and design and construction to generate a score. It has become increasingly integrated into the performance measurement of publicly-funded homes and its principles are embodied in the HCA's criteria for funding, requiring a minimum score of twelve against the twenty criteria detailed in the Building for Life

[23] http://buildingfor life.org.uk

publication Delivering Great Places to Live (2008), in order to secure NAHP funding.

For Smith Lane, the local authority is one of the fifteen councils, including Smith Lane's county council, that has integrated the principles of Building for Life into its policy framework.

4.9.2 Additional design requirements - summary

The four requirements noted above, in addition to the Code for Sustainable Homes, have a direct relevance to the vision, conditions and design of Project A and are included as part of the analysis of the interaction environment. The origin and impact of these is extracted from Figure 4.2 and shown in Figure 4.3

Figure 4.3 Additional given environment design requirements for Smith Lane

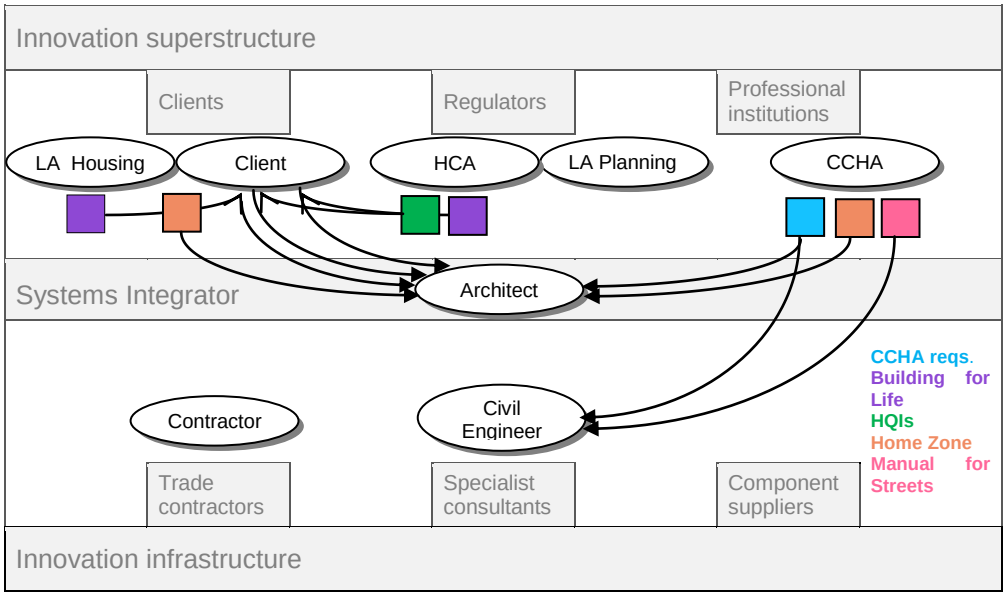


Figure 4.3 demonstrates that the design requirements originate from the clients, regulators and professional institutions and primarily impact on the architect. However, Figure 4.3 also shows that there are intermediate pressures within this group of organisations, and the requirements of the

HCA, as the grant provider, is shown to be pivotal to the project, rather than the client's design brief which serves to channel these to the architect.

Specifically, the Code for Sustainable Homes defines the vision of the project, originating from the local authority's housing team and with an impact on the client, but the HCA grant level, enabling the client to part-fund the contractor to deliver the Smith Lane homes, is set by the HCA and provides the financial framework for the project. The Housing Quality Indicators and Building for Life guides define a series of quality standards applicable for social housing, within a scheme design that makes use of Manual for Streets as a national new street standard using, for Smith Lane, Home Zone principles.

These provide a comprehensive, often complex and overlapping framework of new or recent requirements enacted by organisations in the innovation superstructure – specifically for Smith Lane, the local authority housing team, the Homes and Communities Agency and the county council's Highway Authority. The innovation infrastructure - specifically for the early stages of the inception and design of Smith Lane, the architect, engineer and contractor - works within this framework to generate innovative, cost-effective solutions that meet these requirements in addition to the Code for Sustainable Homes.

The key finding for this section of the analysis is expressed as:

Finding Three: The Code is just one of a range of complex and overlapping design requirements and regulations identified by project participants that exert varying levels of traction on the design process.

4.10 Research Question One - summary

The given environment for Project A, as expressed by project participants, includes the Code for Sustainable Home, and the impact of the Code at the levels of the CoPS model at project, organisation and sector level has been discussed. The impact of the perceived additional costs of meeting the Code, specifically the requirement to reduce CO_2 emissions, was highlighted for both the sector and for end-users. A range of further regulatory requirements were identified and these have been noted and explored to capture the nature of the regulatory landscape and to illustrate that the Code does not exert its impact in isolation.

Having analysed data for Research Question One and discussed the impact of the Code for Sustainable Homes on the early stages of social housing development projects, three key findings have emerged, reiterated here.

Finding One: The impact of the Code for Sustainable Homes at the design stage of social housing development projects is one of negotiation around existing techniques and technologies to define the most cost effective way of achieving CO_2 emission targets within the client's social housing grant and the contractor's financial model.

Finding Two: The physical limitations of the site and the requirements of the road layout may impact on the space available for the number of homes defined for the development and for their orientation and placement to optimise solar gain and to accommodate external Code features such as water butts, cycle storage and composting.

Finding Three: The Code is just one of a range of complex and overlapping design requirements and regulations identified by project participants that exert varying levels of traction on the design process.

The interaction environment, as the arena for addressing the requirements of and generating innovative responses to the Code within a complex regulatory framework is considered next.

4.11 Research Question Two - how do social housing development projects innovate to meet the Code for Sustainable Homes?

4.11.1 Introduction

Having addressed Research Question One on the regulatory impact of the Code for Sustainable Homes on the early stages of social housing development, Research Question Two considers how social housing development project teams innovate to meet the requirements of the Code during these early stages. This is achieved by identifying innovation in response to the Code (defined as the process of the successful application of new ideas that generate value) within the interaction environment, and by identifying how the project participants generate innovation.

First, text analysis of data for Research Question Two generates the opportunity to consider the definition of innovation proposed and justified for the research from relevant literature, as 'the process of the successful application of a new idea that adds value' and identify the components of this definition in data generated from Project A's project development practitioners. This will be used to illuminate similarities, to confirm the research definition and also to highlight any variance. This is achieved by assessing answers to the direct interview question 'What do you understand by innovation?' The answers to the question are captured in Table 4.7.

Table 4.7 'What do you understand by innovation?'

Participant	Response
LA Housing	'I see it as being something beyond the bog-standard that we have to do anyway, something that's different.'
Client	'A typical academic question! Different ways of doing things, I suppose, higher benefits.'
HCA	'We have a weekly innovation meeting, chaired by Bob Kerslake[24], on a weekly basis...we want to encourage new starts, so we want to look at new products, new ways of working...'
LA Planning	'I'd say innovation is trying to introduce something new, introducing a new procedure.'
CCHA	'...there are ways and means of being able to adapt roads that don't strictly comply with our published standards.'
Architect	'I've read the Egan report![25]..I believe innovation has come into every scheme we've worked on.'
Contractor	'Innovation is the evolving of methods to do something – not always physical but ideas as well.'
Civil Engineer	'...a tricky question! It's trying to develop a scheme that the client desires within the confines of what we have to do...'

The common themes from these transcript extracts are the newness and difference from current practice and the awareness of the need to achieve this within existing boundaries. Value (in terms of increased benefits) is also noted. For the research definition of innovation as 'the process of the successful application of new ideas that add value', the extracts at Table 4.7 suggest the addition of a phrase to recognise the limitations of the given environment, for example 'the process of the successful application, within existing regulatory constraints, of new ideas that add value'. Although this perpetuates the model of incremental innovation identified in housing construction literature, the 'existing regulatory constraints' within which the design of Smith Lane took place were both real and typical for the project participants.

There are three stages to the analysis strategy for Research Question Two. First, innovation is identified within the case study as a series of

[24] HCA Chief Executive 2008 - 2010

[25] The influential 1998 Egan report 'Rethinking Construction reported 'the scope for improving the quality and efficiency of UK construction' (Kagioglou et al., 2008: 141).

responses to the Code and to the additional regulatory requirements within the given environment. Additionally, analysis of data generated evidence of explorative innovation that was not in response to regulatory or other drivers located in the given environment of either the project or the project's participating organisations, and this is used to add depth and richness to the Research Question. Innovation located within the case study data is identified and assessed in terms of innovation category (broadly, product; process; position or paradigm) as identified by Francis and Bessant (2005) and type (incremental; modular; architectural or radical) as discussed by Henderson and Clark (1990).

Secondly, the process which generates innovation within the interaction environment of the project is identified from case study transcripts as one of iteration, negotiation, compromise and solution, and these elements are mapped within the hierarchy of superstructure and infrastructure of Winch's (1998) model of innovation in construction as a complex product system (CoPS). At the same time, this dynamic process acknowledges Van de Ven et al's (2008) seminal work on the innovation journey, from which many characteristics are recognisable in Project A's dynamic innovation. The analysis of the process that generates innovation is extended and complemented with a consideration of the dynamics of the project team that emerged from data collected which provides an additional layer of context to the design process for Smith Lane.

Thirdly, the two analyses of innovation and of its contributory processes, as identified within the case study data, are synthesised to demonstrate that a housing development design project is a complex, dynamic and responsive process within which explorative innovation takes place. The context of an array of external regulatory factors in the given environment cultivates a dynamic and resourceful interaction environment as the locus within which Project A's participants address the design of Smith Lane.

4.12 Innovation in Project A

Innovation has been defined, within the context of the research, as 'the process of the successful application of a new idea that adds value'. Case study data has been analysed by coding instances of innovation in NVivo, using project participants' own descriptions of innovation and extending this with evidence of innovation not described by participants as innovation. Characteristics of newness or novelty, and the potential addition of value to the design of Smith Lane were identified and, based on these criteria, fifteen examples of innovation were identified in data collected for the Smith Lane case study, and are summarised in Table 4.8.

Four of the fifteen examples are relevant for the case study. Innovations 1 and 2 are considered in detail as an integral part of the research question on innovation to meet the Code. Innovations 3 and 4 are considered because they are in response to additional regulatory design requirements for Smith Lane arising from the introduction of Manual for Streets. Further innovation listed in Table 4.8 is captured and described at Appendix 4.4 as a record both of innovation in the early stages of Smith Lane and as evidence of additional innovation from case study data that is not directly relevant to the design of the Smith Lane, to show that, within a project environment, ideas that potentially add value, either to the project or to an organisation, emerge.

Table 4.8 Innovation identified in Project A.

	Innovation	Regulation	Smith Lane
1	Design to reduce energy demand	Code	Yes
2	Selection of renewable energy sources	Code	Yes
3	Geometry of street layout for Smith Lane site	Manual for Streets	Yes
4	Geometry of visibility splays on entrance to Smith Lane	Manual for Streets	Yes
5	Giving away council land	None	Yes
6	Approach to the issue of the Smith Lane ransom strip	None	Yes
7	Round-table meeting to push progress to achieve planning permission	None	Yes
8	Arrangement to ringfence sales proceeds	None	Yes
9	'Unbundled parking'	None	No
10	Provision of less road and more private drive	None	No
11	'A master plan that changes everything'	None	No
12	Past innovation in construction methods	None	No
13	Standardisation of house types	None	No
14	Homebuyer Direct product	None	No
15	Code 5 housing with education / training / demonstration facilities	None	No

Meeting the Code for Sustainable Homes level 4 is the vision for Project A and innovation in response to the Code is evident in project data, however the innovation identified that is relevant for the Code is not expressed by project participants as a range of new products that characterise incremental innovation, nor as potentially radical changes to the way that homes are designed that will alter the way that they are occupied. Instead, meeting the mandatory requirement of Code 4's CO_2 reduction target of 44% is identified as a cautious, cost-driven approach to combining existing building techniques with more recent technologies, to achieve the CO_2 reduction target of 44%, where innovation can be defined as an assessment of the optimum the mix of existing techniques and technologies. Water use reduction, as the second mandatory target for Code 4, is addressed with, for example, the use of low-flow aerating taps.

Additional Code criteria, such as the provision of recycling storage, are designed in for minimal additional build cost.

The two specific innovations identified from the research data that have been developed to meet Code 4's CO_2 reduction target of 44% (based on 2006 Building Regulations Part L), identified in Table 4.8 as design to reduce energy demand and the selection of renewable energy technologies and hardware to meet residual demand within the sources, are addressed separately below and the issues arising are synthesised to reflect this specific part of the given regulatory environment in which housing development project teams interact.

4.12.1 Innovation 1: design to reduce energy demand (Ene 2)

This innovation is summarised as a 'fabric first' approach, using existing housing construction techniques to provide a cost-effective starting point for reduction of energy demand and therefore CO_2 emissions to meet the Code target, specifically addressing the Code's Ene 2 criterion. This is not, in itself, a mandatory criterion for the Code, however its contribution to the reduced 44% DER (Dwelling Emission Rate) target at Ene 1 is significant. The key project organisations in the development of an innovative approach to the use of building fabric to reduce CO_2 emissions are the client, architect and contractor, representing Complex Product System roles of superstructure, System Integrator and infrastructure respectively. The innovation itself is defined as an incremental product innovation in that it applies and reconfigures existing techniques.

The role of the client housing association is critical in the development of this innovation. Their approach for delivering the Code for Sustainable Homes is included in the Design Brief[26], noting preferences for project team partners to use in designing homes to meet Code 3 housing as the

[26] The client's 76-page Design Brief 2008 has a 6 page section on the Code for Sustainable Homes.

required Homes and Communities Agency minimum standard for the 2006 – 2011 NAHP programme. The Design Brief represents an additional layer of guidance for the architect and contractor, although the client notes that they are happy to consider alternatives and adjustments to meet their criteria. The preferred approach is to adapt Passivhaus[27] principles of built envelope efficiency to achieve 'the highest affordable level of passive fabric insulation' (client's Group Design Brief, 2008:10) to meet the Code for Sustainable Home's Ene 2 Building Fabric element. This is not a mandatory element within the Code, however the client's Design Brief, in specifying the Building Regulation measurement for air leakage as 'not to exceed 5 cu.m/hr/sq.m @ 50 pa' (Group Design Brief, 2008:10) emphasises the preference for a 'fabric first' approach to design.

The client's specification of high levels of passive fabric insulation is mirrored in the contractor's focus on the cost of building homes to meet Code 4. The response to the regulatory burden placed on the construction sector is primarily expressed as additional cost, and innovation to meet the Code is defined in terms of cost by the contractor.

> *'...increasing the width of the cavity and doubling the amount of insulation is one of the cheapest ways of improving thermal performance ' (Contractor).*

Having recognised that the primary response to the Code is the reduction of energy demand by increasing thermal performance as a cost-effective use of existing building techniques informed by Passivhaus principles, the use of an innovative and optimal cost-effective mix of additional technologies to achieve Code 4's 44% CO_2 reduction requirement is addressed.

[27] Passivhaus is an international energy performance standard for new housing based on achieving excellent thermal performance and airtightness to reduce the need for conventional heating (http://www.passivhaus.org.uk)
.

4.12.2 Innovation 2: selection of combination of facilities to generate energy (Ene 7)

This innovation is summarised as the costing of combinations of available technologies to contribute to the CO_2 reduction target of 44%, having designed affordable thermal efficiency into the fabric of the buildings as expressed in Innovation 1. The regulatory driver is Ene 7 (Low carbon technologies) of the Code for Sustainable Homes, and the client's Design Guide provides the immediate framework for the potential options. The innovation is evolved by the architect and the contractor, as the Systems Integrator and the innovation infrastructure of the project, and the innovation, as a combination of existing technologies, is defined as incremental.

The client's Design Guide specifies mains gas, where available, as the preferred primary source of space and water heating and, where the combination of this within a well-insulated home does not meet the DER standard, alternative sources are ordered as follows[28]:

1 Solar hot water generation
2 Air source heat pumps
3 Ground source heat pumps
4 Biomass communal heating

The ongoing useful life, maintenance cost and ease of use for residents of these options is to be considered with Asset Management and Housing Management colleagues, and 'a single system of higher output is preferred to the use of multiple technologies' (client's Design Guide, 2010:10), thus innovation in energy options to meet Code 4 requirements for Smith Lane needs to accommodate this guidance.

[28] The use of solar power to generate electricity is not included in this list. This apparent omission may be taken as evidence of the rate not only of the development of solar panels as a supply chain product, but also the knowledge and acceptance of these as a potential realistic source of power at the time of the case study interviews.

For Project A, the client's Design Brief (2008) defines preferences for ways of meeting Ene 7, from which the contractor and architect developed a range of solutions. The potential options for meeting the specified TERs (Target Emission Rates) were specified by the architect for the contractor to cost as part of their financial assessment. The architect's approach combines the 'fabric first' principles championed by the client and contractor with additional technologies and the architect's energy options schedule at Appendix 4.5 reflects a mix of increased insulation, high specification gas heating and renewable energy sources. This is defined as innovative in that the approach, of assessing and summarising different potential mixes to meet Code criteria Ene 2 (building fabric heat loss parameters) and Ene 7 (renewable energy sources), is new to the architectural practice and adds value by extending expertise in energy-efficient technologies and the cost-effective combinations of these.

The architect's energy options spreadsheet at Appendix 4.5 is based on four sample properties at Smith Lane of different sizes and orientations, with common design features including solar panels, cylinders and solar store (the first of the client's preferred options for additional energy sources) and four possible energy options for each sample property.

- Option A includes a boiler and photovoltaic panels.
- Option B replaces the boiler with an air source heat pump, a gas fire to compensate for any cold weather shortfall and increased solar panel size. The architect notes that the available roof space may not accommodate the required increase in solar panel size to achieve the overall target DER for this option. In addition, air source heat pumps are the client's third (of four) preferred options for alternative energy sources.
- Option C is similar to Option B, with a more efficient gas fire.
- Option D replaces the air source heat pump with a ground source heat pump and replicates Option C's gas fire.

All options for each of the sample property types achieve or exceed the calculated DER score to achieve the 44% minimum CO_2 emission reduction target, summarised at Table 4.9. The lowest DER for each option is highlighted, and the nearest to the target DER (the highest) is in italics (where the lower calculated result is better).

Table 4.9 Comparison of DERs for energy options

Plot	1	11	15	43
TER	11.72	12.92	13.11	14.91
Option A	11.71	12.82	12.97	*14.73*
Option B	*11.72*	*12.90*	*13.11*	14.48
Option C	11.58	**12.72**	13.01	14.09
Option D	**11.43**	12.75	**12.8**	**13.91**

Option B, the nearest to the DER for plots 1, 11 and 15, uses air source heat pumps, the client's third (of four) preferred options for alternative energy sources. Option D, using ground source heat pumps (the client's second preference), returns the lowest DER for plots 1, 15 and 43.

Additionally, the architect made use of property orientation to optimise solar gain on north / south facing homes, to include potential shading for south-facing windows.

The schedule provides the contractor with information for costing the range of potential solutions to inform a final decision on an energy option for Smith Lane that meets the client's preferences as expressed in the Design Guide and budget for the project, and the contractor's formal Board approval.

Part of the way through the Smith Lane development project (and after the case study timeframe) the contractor decided to pull out of the Smith Lane development project. The specific impact of this on analysis of Research

Question Two is that information on the eventual agreement on and costing of a solution, and the decisions that supported, it is not available.

4.12.3 Innovation to meet the Code in Project A – summary

This method of 'fabric first' (Ene 2) and additional technologies (Ene 7) identified in the case study data is noted by the Energy Saving Trust as a short-term 'cost-effective alternative solution' (EST 2008: 3) bridging the gap between pre-Code housing and the radical solutions for energy performance technologies anticipated for meeting Ene 1's 100% CO_2 emission reduction targets for Codes 5 and 6 from 2016. For Project A, the innovation to meet the Code for Sustainable Homes' requirement to reduce CO_2 emissions occurs at the intersection of the client's need to work within social housing's grant funding regime with its associated quality conditions and timescales and the contractor's commercial driver to deliver optimum profitability within the client's brief. This intersection is located with the architect as an expert integrator of the two perspectives, as discussed in Chapter Three: Methodology, Section 3.10. This representation restates Winch's model of innovation in Complex Product Systems, however it overtly includes regulation as a driver of innovation, which for Project A is expressed as new combinations of existing established and recent products and processes, and where the innovation is in defining a workable combination of these to achieve the required CO_2 emission.

The key finding summarised from analysis to identify innovation to meet Code level 4 is expressed as follows.

Finding Four: Innovation to meet Code level 4 has been identified as predominantly, incremental, exploring combinations of existing established and recent products and processes to achieve the required CO_2 emission reduction.

Having explored the key innovation for Smith Lane in relation to meeting the requirements of the Code for Sustainable Homes as the mix of building techniques (Ene 2) and technologies (Ene 7) for achieving the mandatory Ene 1 element of CO_2 reduction, two additional innovations identified during data analysis as noted in Section 4.7.2 and listed in Table 4.8 that are relevant to the design of Smith Lane are noted below.

4.13 Additional innovation for Smith Lane

The significance of these innovations in response to a further newly-introduced regulatory requirement is considerable for the research and this is reflected in the analysis below. The additional innovations, as listed in Table 4.8, are included to demonstrate that Smith Lane's project team, in responding to the given environment within an interaction environment, generated solutions in response to the significant additional regulatory requirement of the Manual for Streets adopted by Project A's county council Design and Movement Guide. Innovation 3 considers the design of the street geometry of Smith Lane's site layout, and Innovation 4 specifically considers the design of the visibility splays at Smith Lane's entrance.

4.13.1 Innovation 3: geometry of street layout for Smith Lane site

This innovation is summarised as the design of the 'legibility of priority' of the road around the Smith Lane site, acting as an informal one way system and including the detail of the junction in Figure 4.4, so that

'no-one in their right minds needs to turn right ... because there's nowhere to go' (CCHA team leader).

Figure 4.4 'The legibility of priority' - informal one-way system around Smith Lane.

Figure 4.4 is a detail of the client's housing plan for the eventual layout of Smith Lane (extracted from Figure 3.5 in Chapter 3, Section 3.11) which replicates the case study's original plan for street geometry, accompanied by an extract of the engineering plan for road layout where the red arrows indicate the obvious left turn into the road loop. The full engineering plan of the visibility splays of the road bends within the site is included at Appendix 4.6, showing the innovative geometry of the street layout for the site within which this informal one-way system operates.

The regulatory driver for this unique geometry is the new standards, approach and rationale for shared street use expressed by the Manual for Streets, as adapted within the county council's Place and Movement Guide. The key project participants for this innovation are the CCHA, within the CoPS superstructure, working closely with the engineer within the CoPS infrastructure. The innovation of the layout adopted by the development team can be characterised as a product innovation in that the street, when constructed, will function as an ordinary one-way system designed within the use of existing geometric principles.

4.13.2 Innovation 4: geometry of visibility splays on entrance to Smith Lane

This innovation is described as a 'double squiggle' visibility splay at the entrance to the Smith Lane site by the CCHA team leader. Although this 'doesn't comply with any known adoptable standards' (CCHA team leader) it accommodates the County Council's requirements for controlling speed and promoting safety. Figure 4.5 locates this on the client's plan for Smith Lane and includes an extract of the engineer's plan.

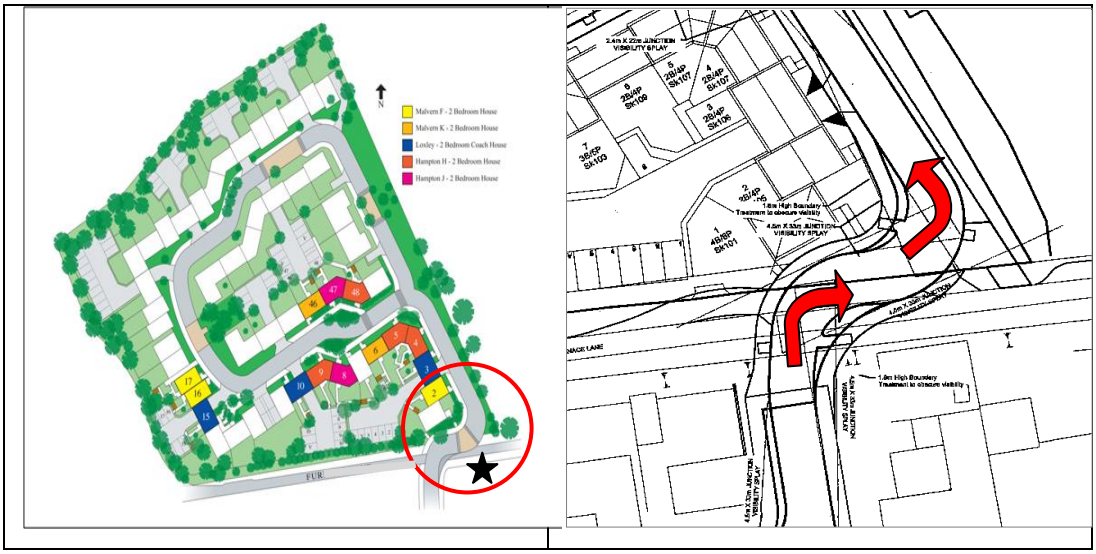


Figure 4.5 'The double squiggle' - entrance to Smith Lane

The two constraining factors for the design of the entrance to the Smith Lane site were first; the single point of access requiring the design of a road wide enough for two vehicles to pass each-other in opposite directions, extending from the road from the adjoining site, and secondly; the ownership of the small area of land marked by the black star. These constraints defined both a tight bend and limited visibility for the access, and promoted the innovation necessary for the imaginative design of the entrance where a traditional or conventional approach would not have possible.

Again, the regulatory driver is the County Council's Place and Movement Guide, and the key project participants were the CCHA team leader in the innovation superstructure, seeing regulation as an enabler of innovation, in collaboration with the engineer within the innovation infrastructure, generating a workable and effective solution. The eventual solution is a product innovation which is incremental in that it uses the existing geometry of engineering principles to address the specific issues of access into the Smith Lane site.

Within the overall design of the Smith Lane's street layout, the successful development of entrance to the site is of particular importance. As an innovation, the value of the design of the entrance is in its contribution to the scheme, which would not otherwise have been viable. Although the regulations and restrictions promoted a unique innovation solution, the relevance to the delivery of a Code 4 scheme is minimal. However, the innovation is highlighted as additional evidence of exploratory innovation in project working.

4.14 Additional innovation for Smith Lane - summary

The previous section considered two additional innovations which were generated in response to constraints within Project A's given environment; both the physical constraints of the site and the requirement enacted by the County Council's Highways Authority to meet requirements for designing a road layout that meets speed, safety and access requirements. Four additional examples of innovation arising from case study data in the context of Smith Lane, and seven other examples used by interviewees to illustrate or extend their narratives, listed at Table 4.7, are included at Appendix 4.4. This appendix emphasises that innovation to meet the Code for Sustainable Homes does not happen in isolation, but as part of a shared and complex response by project partners to the given environment which includes national, regional and local design requirements and a range of organisation-specific requirements.

Evidence of innovation processes are explored below to illuminate the second element of Research Question Two: how do social housing development project teams innovate to meet regulations.

4.15 How do social housing development project teams innovate to meet regulations?

Having identified a range of innovation within Project A, content analysis of research data is used to provide evidence of how Smith Lane's design team generated innovation to meet regulatory requirements. The aim here is to use the narratives of the eight project partners to propose and validate a potential sequence of events, using the four innovations directly associated with the response to regulatory design standards for Smith Lane noted above, that illuminate the process of innovation.

The case study data supporting the Code for Sustainable Homes level 4 as the primary focus of the research, and Manual for Streets as a secondary requirement emerging from data, as the two key regulatory requirements for the design of Smith Lane, are used to provide evidence for four elements of iteration, negotiation, compromise and solution identified in the generation of innovation to meet these two requirements. Although definitions of these four elements are carefully expressed for the purposes of content analysis, similarities exist between them and these contribute to some inevitable overlapping of both analysis and discussion.

First, consideration of these elements in the context of the CO_2 reduction target shows how the project team work towards an innovative and cost-effective combination of existing building techniques and recent technologies. Secondly, the process for achieving a solution for meeting Manual for Streets is compared, and other examples are identified and included as appropriate. This analysis contributes to the resolution of Research Question Two, illuminating how Smith Lane's design team

innovated to meet these regulations and proposing a four-stage process for innovation in response to regulation.

The categories for the four-stage process, of iteration, negotiation, compromise and solution, emerged both quickly and decisively for the researcher following several days of focus and reflection on the interview transcripts to illuminate and characterise the innovation process. These capture the process and are used as a framework for analysis for Research Question Two.

4.15.1 Evidence of iteration

Iteration is defined for the research as 'the repetition of a process...typically as a means of obtaining successively closer approximations to the solution of a problem' (Oxford Dictionaries Online). This definition extends the concept of mere repetition to the arrival at an eventual solution. Iteration as both repetition and solution are identified in content analysis of case study data and this is used to propose iteration as the first of four elements of innovation in response to regulation in early housing design projects.

Within the context of Project A, iteration is the 'back and forth' of the process of a project which can take time as a valuable, and therefore costly, project resource. The iterative process is described by the architect and the engineer, as project participants actively involved in the layout and design of Smith Lane, as a normal part of their business involvement. The architect characterised the process as a blank sheet of paper which accumulates and refines information and detail over time, echoing the dictionary definition noted above:

> *'every time someone else sees the drawings, there's something coming in so it's a continuous process' (Architect).*

The architect described the volume of sketches and plans, with freehand sketches amount to 'hundreds', house plans that have been revised 'three or four times' and '...there must be about 8' versions of the site layout. The engineer described

'a process, going backwards and forwards, changing bits here and there till you're happy you have a layout'

and the CCHA team leader noted that

'what you see on the ground is the result of applying a number of different criteria, which builds up the shape based on reality'.

However, both the contractor and the client viewed the iterative process described by the architect, engineer and CCHA (noted above) as normal, in terms of frustration and stagnation. The contractor described

'going round in circles'

to reach a solution that could be costed to everyone's satisfaction, and the client noted

'going round and round in circles' ... 'taking ages',

reflecting on behalf of the architect,

'he's borne the brunt of it - the number of times he's had to revise his layouts...'.

For Project A, there were more iteration events, taking more time, than expected for a standard development. In particular, the development of the innovative entrance to the scheme by the engineer and architect, working closely with the CCHA team leader in response to Highway Authority requirements, required several iterations. Evidence of iteration associated with building to Code 4 focussed on the architect's development of energy options and the contractor's costing of these.

4.15.2 Evidence of negotiation

Negotiation is defined within the research as **'**discussion aimed at reaching an agreement' (Oxford Dictionaries Online). The iterative process identified above involves a series of negotiations between the decision-makers of project organisations, showing a motivation to work through alternatives. Projects are defined as collaborative engagements 'so almost all innovation(s) have to be negotiated with one or more actors in the project coalition' (Winch 1998:273). Content analysis of case study data identified elements of positive discussion as part of the process of innovation in response to regulation, with the following findings.

Negotiation for achieving the CO_2 reductions required by the Code for Sustainable Homes level 4 was based on multiple conversations and letters between the architect and contractor, described by them during the semi-structured interviews. Their conversations focussed on the potential technical and cost options within the grant constraints of the client's financial model as defined by the Homes and Communities Agency's funding regime. For Project A the role of the architect, as a Systems Integrator, included the production of a comprehensive schedule of options for meeting CO_2 emission improvements (included at Appendix 4.5.

> *'[the contractor] has asked me to look at alternatives for Energy1 in the Code, seeing which is the most efficient as far as we're concerned and which is most economical as far as he's concerned' (Architect).*

The contractor, as the second key participant in this process, defines economy as cost-effectiveness, where solar panels alone will not meet the 44% CO_2 reduction required by Code 4 and the client would prefer not to have air source heat pumps.

The negotiation between the architect, as Systems Integrator, and the contractor within the innovation infrastructure of Winch's (1997) CoPS

model relates to the efficiency and economy of energy alternatives to meet Code 4's Ene 1 requirement, which took place in a dynamic process over a number of weeks during the early housing design phase. This process generated a volume of detailed work for both the architect and the contractor which would not normally have occurred at this early stage in a non-Code project.

The aim of this negotiation was to enable the contractor to generate a detailed costing as part of the development contract with the client, and the architect justified his role as System Integrator with expert knowledge of the potential combinations of technical options presented by the specific design constraints of the site, incorporating, for example, orientation of homes to optimise solar gain.

Negotiation around the innovative road layout for Smith Lane within the Manual for Streets guidance was generated by the engineer in conjunction with the architect, client and CCHA team leader, who had given advice:

'just because we give a particular piece of advice doesn't mean to say that there isn't an alternative solution that would be equally acceptable' (CCHA),

even though the engineer noted that

'it took us quite a while to get an agreement from Highways on providing this double bend speed control'.

Additional evidence of three instances of negotiation that did not specifically generate innovation in response to regulatory requirements was also identified within case study data and these are noted. First, the HCA were prepared to review the client's grant allocation for Smith Lane and negotiate a potential re-allocation of funding across two projects. Secondly, the clients' Design Brief gives development partners an

indication on their preferences for achieving level 4, expressing a willingness to negotiate solutions:

'It's not an imposition or an obligation on them – we are mindful that there are so many different ways of skinning a cat' (Client).

Thirdly, the height of properties at the north of the site was negotiated between the architect and engineer to accommodate Smith Lane's road engineering constraints and the noise from the dual carriageway to the north of the site.

These additional examples are noted to support evidence of the culture of negotiation in the context of the project's interaction environment, operating across the hierarchy of the CoPS model of the innovation superstructure and infrastructure, within which negotiation around innovation to meet regulatory requirements takes place.

4.15.3 Evidence of compromise

Compromise is defined as an 'agreement or settlement ...that is reached by each side making concessions...so that an intermediate state is achieved between alternatives, reached by...mutual concession' (Oxford Dictionaries Online). It suggests that potentially opposing interests exist and that concessionary positions between parties can generate solutions. Within the case study's interaction environment, the reality of compromise is finely nuanced within the professional relationships, interests and drivers of the project participants and the subtle evidence of compromise is identified through content analysis and noted in the context of innovation in response to regulation to meet the Code and Manual for Streets.

The contractor, whose primary driver within the interaction environment is to ensure that build costs fall within the organisation's profit model, notes that the use of solar panels is costly and will not meet the Code's Ene 1 mandatory requirement of 44% reduction of CO_2, but the addition of air

source heat pumps can be used to meet the shortfall. However, the clients' preference is for another supplementary heat source because air source heat pumps failed on a different site when the outside temperature was too low. The compromise for this conflict is the detailed assessment and costing of alternatives by the architect and the contractor to meet the 44% reduction in conjunction with solar panels, discussed in Section 4.12.2 and included at Appendix 4.5.

The stated preference of the local authority, supported by the architect, was for a Home Zone style of street layout for Smith Lane without footpaths, to promote a shared ownership of the road. However, the CCHA's adoption of the principles of Manual for Streets implies traditional footpaths and

'unfortunately we haven't got quite what we require either way' (Architect)

with the compromise being a single footpath and speed tables to slow traffic down. An additional compromise is the use of sharp corners and chicanes preferred by the architect, and speed tables and varied road width defined in Manual for Streets and preferred by the CCHA, as ways of slowing traffic around the site.

The design of Smith Lane's housing to meet the Code level 4 and the road layout to meet the county council's design guide which incorporates the new Manual for Streets are key aspects of the case study and evidence of compromise between project participants in addressing these adds value to the research findings.

4.15.4 Evidence of solution

Solution is defined as 'means of solving a problem', 'the correct answer to a puzzle' and a 'product or service designed to meet a particular need ' (Oxford Dictionaries Online). For this research, elements of all three

definitions are noted, in addition to representing the culmination or end-point of iteration, negotiation and compromise in the development of innovation and in addition to the application of existing design techniques within the project's interaction environment.

For the case study, the solution is the culmination of a series of iteration, negotiation and compromise events, expressed as the version of the design that is formally approved by another agent or project participant. A solution emerges at a point in time and includes innovation in response to new regulatory requirements in conjunction with existing scheme design processes and techniques. Within the case study, solutions are confirmed at the following four points:

1. The approval by the county council's Highway Authority of the layout of Smith Lane.

This included approval for two innovative design features for Smith Lane; first, the entrance to the road loop around the site, where the one way traffic flow required by the number of homes on the site was defined by the unique design of the first bend forcing drivers to follow the road to the left (detailed in Section 4.13.1); and secondly the double bend at the site entrance, accommodating the constraints of a tight bend and limited visibility and addressed with imaginative geometry (detailed in Section 4.13.2). These details are within the overall road layout for the Smith Lane site, meeting the requirements for the safety of all road users through the design of features to control the speed of vehicles. These are defined in the newly-published Manual for Streets as expressed by the county council's Place and Movement Guide in conjunction with the principles of Home Zone as required for Smith Lane by the local authority housing team as part of the condition of giving the land to the client.

2. The freezing of the scheme design by the client.

This is a formal stage in the client's Global Development Process Map, and is expressed as the point

'...when everybody, all the stakeholders, say 'we're happy'' (Client)

as part of a Design Freeze meeting.

3. The approval of the contractors' Board for the construction contract.

The contractors' Board supported Project A in principle following the Design Freeze meeting. (However the impact of the subsequent collapse of the housing market on the capacity of the homes for sale within Smith Lane to support the finance model led to a re-negotiation of the HCA's grant and a re-agreement of a lower contract price. The accommodation of the resultant deficit in the cost model required further Board approval, which was rejected and the development, for the contractors, was aborted).

4. The granting of planning permission for the scheme by the local authority's planning team.

The first submission for planning approval was refused on the grounds of concerns on noise levels for plots next to the dual carriageway. Following additional noise and vibration testing and a minor amendment of the design, planning permission was granted.

4.16 Innovation process - summary and findings

The identification of the four specific elements of iteration, negotiation, compromise and solution arose from a detailed consideration of case study data capturing a complex, dynamic and non-linear project process with multiple constraints and drivers within which innovative solutions were generated and applied by project team members. The power and validity of the use of these four elements to characterise the process of innovation

within the interaction environment of a project design team is supported by the various perspectives of the case study participants as they talk about the process, or the story, of Smith Lane and their shared and individual responses to the challenges and opportunities presented both by the multiple design requirements and the unique physical constraints of the site. Content analysis of the sections of the interview transcripts that included accounts of the processes which were resolved in the four innovative solutions described above indicated the need for a multi- (rather than a single) stranded model and the use of iteration, negotiation, compromise and solution to describe and capture the strands has been shown to be both appropriate and apposite.

The key finding for this section of the analysis, on the process for project teams innovating to meet regulations, is expressed as follows.

Finding Five: The innovative process in response to multiple design requirements and constraints is characterised by four distinct yet overlapping elements of iteration, negotiation, compromise and solution.

Within the project environment for Smith Lane and in the context of the development of innovative solutions to meet regulatory design requirements, some evidence of how the team works together emerged and is captured in the next section.

4.17 Teamwork - mapping of professional relationships

The elements of iteration, negotiation, compromise and solution explored above are threads of the complex route for generating innovation that drives incremental improvements to the development process in the context of the multi-organisational project team. Systematic content analysis of the case study data suggested a network of positive, neutral and negative professional relationships and alliances. These are mapped

in relation to the CoPS innovation framework at Figure 4.6 to model any potential links between the relationships as expressed by case study participants and the regulation and innovation of Project A.

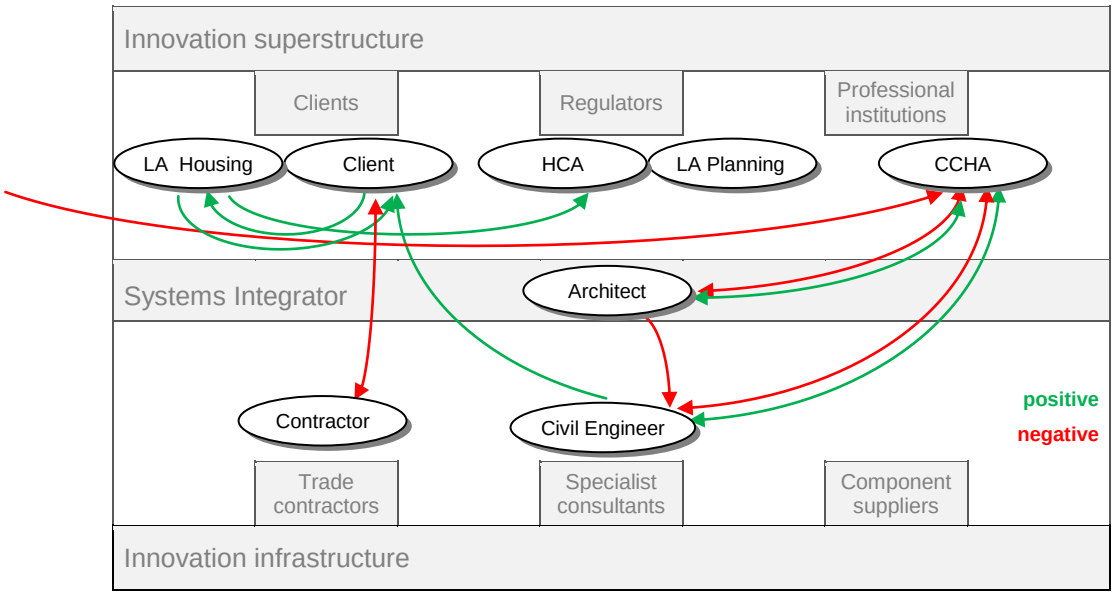


Figure 4.6 Expression of positive and negative relationships in Project A's team

The map of tensions expressed by project team members in the specific context of working to meet regulatory requirements within cost constraints at different stages in Smith Lane's design process captures a complex and often contrary set of professional relationships. Positive and negative relationships were expressed between the same pairs at different times, for example between the CCHA team leader and the architect, and the CCHA team leader and the engineer. These pathways, reflected in Figure 4.6, reflect the project direction and impact of the Code for Sustainable Homes and the county council's Design Guide incorporating Manual for Streets as two new key regulations driving the design of Smith Lane.

The purpose of the identification and discussion of these characteristics here is to capture and reflect the dynamic and fluid nature of the emergence of innovation, in its entirety, as the project team worked towards solutions for the range of issues generated by the development of

Code 4 homes at Smith Lane. The positive and negative expressions captured by Figure 4.6 emerged from analysis of transcribed data and are recognised for their addition of value within the context of the research unit of analysis of innovation in Project A.

4.18 Innovation processes and team processes - synthesis

The synthesis of innovation processes, defined as iteration, negotiation, compromise and solution, and team processes expressed in terms of positive and negative relationships, reflect a series of complex and dynamic responsive manoeuvres within the project's interaction environment that generate innovation to meet the design requirements of the Code for Sustainable Homes level 4 and the site layout as defined by Manual for Streets. These have been captured as part of the thesis to add richness and depth to the findings in response to the two Research Questions.

4.19 Chapter Four: Analysis and discussion - summary

Project A's case study data has been analysed in line with the case study methodology to address the two Research Questions. Findings emerging from the data have been substantiated with additional literature to build a rich and complex account, framed by the CoPS model of innovation. First, the impact of the Code for Sustainable Homes on the early stages of housing development projects as one of two new and significant regulations affecting the design of new housing schemes was illuminated and secondly the processes contributing to innovative solutions to meet these requirements were identified and the five key findings are reiterated here as a conclusion to the Chapter.

Analysis for Research Question One, 'What is the impact of the Code for Sustainable Homes on the early stages of social housing development projects', located within the project's given environment as identified by Sexton and Barrett (2003), is summarised in three findings, as follows.

One: The impact of the Code for Sustainable Homes at the design stage of social housing development projects is one of negotiation around existing techniques and technologies to define the most cost effective way of achieving CO_2 emission targets within the client's social housing grant and the contractor's financial model.

Two: The physical limitations of the site and the requirements of the road layout may impact on the space available for the number of homes defined for the development and for their orientation and placement to optimise solar gain and to accommodate external Code features such as water butts, cycle storage and composting.

Three: The Code is just one of a range of complex and overlapping design requirements and regulations identified by project participants that exert varying levels of traction on the design process.

Analysis for Research Question Two 'How do social housing development projects innovate to meet the Code for Sustainable Homes?' is located within the project's interaction environment. Analysis identified first, the full range of innovation generated within the project and secondly, the processes that contribute to the generation of innovation in response to regulation. Two key findings summarise this analysis.

Four: Innovation to meet Code level 4 has been identified as predominantly, incremental, exploring combinations of existing established and recent products and processes to achieve the required CO_2 emission reduction.

Five: The innovative process in response to multiple design requirements and constraints is characterised by four distinct yet overlapping elements of iteration, negotiation, compromise and solution.

Chapter Five concludes the thesis with a critical review of the research process and an assessment of its contribution to knowledge.

**The Code for Sustainable Homes:
what are the innovation implications
for the social housing development sector?**

Chapter Five: Research conclusions

5.1 Introduction

This final chapter concludes the research. It presents a critical review of the research process by considering the extent to which its aim and objectives have been met. It assesses the research against the standards for good qualitative research and notes that its validity and reliability can be defended. It summarises the implications for academic theory and for practice arising from the five key research findings and outlines two potential areas that would merit further research. Finally, it presents the current position of the Code for Sustainable Homes in practice and in literature.

5.2 Meeting the research aim and objectives

The aim of the research was expressed in Chapter One, Section 1.3 as 'to extend and strengthen theoretical understanding of the links between regulation and innovation for the housing development project sector by using an exploratory case study of innovation in the early design stages of a new housing project designed to meet the Code for Sustainable Homes level 4'.

The three objectives were defined to enable the aim to be met, noted below and followed by a reflection on the extent to which they were achieved.

5.2.1 Meeting Objective One

Objective One is 'a review and synthesis of construction and relevant associated literature to define innovation, regulations and projects; to consider the nature of the relationship between these; to assess the nature of innovation within the housing development projects and to inform the research questions'.

The literature review evolved as a kaleidoscope of general, construction and housing references at three levels of innovation, projects and

regulation, and the identification of the overlaps and intersections between these elements. The research challenge was to develop a coherent linear narrative to capture the key literature for each element, at the same time as maintaining a coordinated overview. The synthesis of the literature review, which informed the two research questions, evolved comparatively easily thus justifying the preceding structure and meeting the research objective.

5.2.2 Meeting Objective Two

Objective Two is 'investigation of the assimilation of the Code in the regulatory landscape of the social housing development project sector using a single exploratory case study'.

The use of a single case study as an appropriate methodology for investigating the impact of the Code was considered and justified. Although the case selected for study generated a significant amount of data on the Code from the perspectives of a range of participants, this was in the context of messy, complex, 'real world' situation of the early design phases of a housing project and the eventual analysis of the assimilation of the Code to address the research questions recognised this context and did not seek to isolate its impact. Within this framework, the objective was achieved and contributed to the overall aim of the research.

5.2.3 Meeting Objective Three

Objective Three is 'a critical examination of the Code for Sustainable Homes as a potential driver of innovation, reflected in the unit of analysis of innovation to achieve Code level 4'.

Case study data was used to identify evidence of innovation generated in response to the Code. Additionally, the nature of the case study project generated additional innovation which was used both to extend evidence of innovation in response to regulation, and to emphasise the exploratory

nature of innovation within a project context. Again, the objective is assessed as having been achieved.

5.2.4 Meeting the research aim and objectives - summary

The aim of the research was carefully considered and expressed and the function of the three research objectives in supporting the aim has been assessed as appropriate.

5.3 Meeting research standards

The methodology for the research (in Chapter Three) noted the critical conditions of validity and reliability for testing the quality of empirical social research requirements for good social research, and the design of the research case study using Yin's tactics (2003: 34) for meeting these conditions is reviewed.

5.3.1 Construct validity

Construct validity ensures that data collection for research is objective, by defining operational measures. For this research, the definition of 'innovation' as part of the literature review in the context of the research aim acted as an operational measure. The definition of 'project' and 'regulation' enabled a further objective focus on the data. Additionally, construct validity was supported by the convergence provided by independent interviewees' perspectives on a single project and the joint review of the draft case study report during the second workshop.

5.3.2 Internal validity

The internal validity of a good research design recognises and provides tactics for verifying relevant events that cannot be observed by the researcher. For this research, triangulated evidence of innovation in response to regulation was provided by the project team, and rival explanations for such innovation were not recognisable within the context

of the specific research objectives. The models used to frame the research questions (Sexton & Barrett, 2003) and the analysis (Winch, 1998) provided a logical structure for the research process, and again the simplicity and strength of the eight perspectives on a single project provides the practical level of assurance required for internal validity.

5.3.3 External validity

The criticism of the use of a single case study is that it is difficult to generalise its findings and thus external validity, as a key criterion of social science research, can be compromised with this choice of research approach. The potential weakness of a single exploratory case study for this research has been has been recognised, addressed and defended in a theoretical context as part of the research methodology in Chapter Three, Section 3.8 and is critically reviewed in the context of the case study itself in this section.

Project A, as a case study for the research, generated a wide range of data for analysis to answer the two Research Questions. However, Project A itself, as described in its story in Chapter Three, Section 3.11, also had a series of unique characteristics. Although these were discounted for the analysis, they have been recognised in Chapter Three, Section 3.21 to capture the richness and complexity of the Smith Lane design project (Stake, 1995) within which meeting Code 4 was a single, yet significant, feature.

5.3.3.1 Generalisability of Project A's findings

Having noted the unique features of Project A to highlight their omission (as far as possible) from the research analysis in Chapter Four, the generalisability of the key findings is considered to emphasise the external validity of the research.

Although the addition of a further similar case study would have generated further information to triangulate the data from Project A, the volume of homes being designed to Code 4 at the time of the case study data collection phase of the research was limited, as evidenced in Chapter Three, Table 3.5. The justification of a single case study within the research methodology presents a potential limitation to the research in that Project A represents one of four key models of housing development. Table 5.1 summarises the alternatives.

Table 5.1 Organisations initiating property development (adapted from Isaac et al, 2010: 3)

	A	B	C
Organisation type	Commercial volume housebuilder	**Local authority**	Voluntary, charitable or not-for-profit e.g. housing association
Sector	Private	Public	Third sector
Typical scheme	Housing development for sale	New housing for rent	Affordable new housing for sale or rent
Primary motive	Profit	To meet social and economic policy objectives	To meet specific charitable purposes
Primary driver	Purpose of the business	Part of overall local function and strategy	Stock development to meet housing need

Project A is located within the local authority model (column B, highlighted) because the original vision and driver for the construction of an exemplar Code 4 development originated in the local authority housing team. Commercial volume housebuilders will generally build from their range of standard house types. However, although building (or regeneration) for any of the other three models is contracted to commercial housebuilders or to specific companies within their group structures that specialise in affordable housing, the need to meet at least Building Regulations (specifically part L on CO_2 reduction), and the voluntary Code as appropriate, is relevant and thus justifies, to some extent, the generalisability of the research findings.

5.3.4 Reliability

The fourth criterion of good social science research relates to reliability where the goal is to minimise error and bias, such that the same results, findings and conclusions would be reached by a different researcher or at a different time. Although it is likely that a different researcher would have generated similar results using the same research design and case study, the potential for achieving similar results at a different time is less likely because of the exploratory nature of the research into the Code at the time of the data collection.

5.4 Research limitations

Three research limitations can be identified. First, although the research focused on the depth and detail of the early stage of an exemplar housing development built to achieve Code for Sustainable Homes level 4, and the research methodology successfully validated and defended the approach of a single exploratory case study, the research is necessarily confined to a narrow window of opportunity, as technology and approaches to designing and building to Code 4 evolves over time. However, Section 5.6 demonstrates that the research findings contribute to knowledge on innovation in response to regulation in the early phase of projects and thus overcomes the limitations presented by a time-specific case study.

Secondly, an explicit focus on the project context of Smith Lane would have added an extra dimension to the findings and conclusions, specifically in relation to Hansen and Rush (1998:550) who note four potential problem areas associated with innovation in Complex Product Systems (CoPS). One of these is ‘technical uncertainty / difficulties’, and designing to Code 4 as a regulatory requirement is prevalent in the development process mapped for Smith Lane. A second problem area, of ‘organisational and project structure’, as an effect of the involvement of the contractor as a solution to the ransom strip, may also be identified.

5.5 Contribution

The contribution to knowledge arising from the five research findings is strengthened by the topicality of the case study. Collection of case study data coincided with the design of the Smith Lane development at the time of its planning applications, as described in Chapter Three, Section 3.11. The interviewees were thus able to talk about the case study as a key, current issue rather than a historical event and their vivid accounts add a further dimension to the case study data.

5.5.1 Contribution to practice - Findings One and Two

These first two findings are relevant for housing development practitioners and can be regarded as generalisable observations arising from case study analysis, rather than contributions that will change, or affect, the early design process of Code housing.

One: The impact of the Code for Sustainable Homes at the design stage of social housing development projects is one of negotiation around existing techniques and technologies to define the most cost effective way of achieving CO_2 emission targets within the client's social housing grant and the contractor's financial model.

This research finding illuminates the practical tensions of achieving Code accreditation within a social housing grant at the time of the case study. The revision of standard house types by contractors to meet the higher Code levels, and the CO_2 emission targets required by Building Regulations, will address this tension. The uncertainty of being an 'early adopter' of Code 4 for the client in terms of cost of provision and maintenance of new technology is apparent. There is no significant competitive advantage for social housing landlords in providing sustainable rather than traditional housing and the benefits are expressed as increased sector profile.

Because the Code is voluntary, 'home-builders are currently only weakly incentivised to act on sustainability issues in the construction of new homes. The additional construction costs that result from improving the sustainability of homes fall mainly on the developer, while benefits of reduced energy costs are gained by the occupant. Currently there is also little market pull, as sustainability issues still do not tend to be among the highest priorities of the majority of home-buyers. Government intervention is required to address this market failure.' (DCLG, 2009:23)

Two: The physical limitations of the site and the requirements of the road layout may impact on the space available for the number of homes defined for the development and for their orientation and placement to optimise solar gain and to accommodate external Code features such as water butts, cycle storage and composting.

This finding highlights the potential constraints presented by both the size and features of potential development sites and the requirements of road layouts that meet Highway Agency regulatory standards. The design of sustainable housing within these dual constraints relies on the professional knowledge and expertise of the architect working in a project team that is able to both innovate and compromise to achieve the design brief.

5.5.2 Contribution to theory - Findings Three, Four and Five

The research findings that are primarily relevant and generalisable to theory (in that they illuminate and extend current knowledge) are Findings Three, Four and Five, as follows.

Three: The Code is just one of a range of complex and overlapping design requirements and regulations identified by project participants that exert varying levels of traction on the design process.

The research found that regulation in the early phase of social housing design is multiple and often conflicting, brought to the project by its participants. The early phase of the project process is under-researched in construction management literature and specifically, the constraints of regulation and innovative responses within the early phase is therefore not considered. This finding contributes to knowledge generated by the work of Kolltveit and Grønhaug (2004) (noted in Chapter Two, Section 2.11) on the importance of the early phase of construction projects where the potential for innovation is at its highest. Additionally, this research finding shows that the 'project as a temporary organisation' model proposed by Turner (2005), noted in Chapter Two, Section 2.10.1.1 is more complex and nuanced because of the range of organisations within the project at the early stages. Although the shared outcome for the project team is the delivery of 51 new homes built to meet the regulatory requirements of Code for Sustainable Homes level 4, the drivers (and outcomes) for the individual organisations are explicitly described differently by project participants.

Four: Innovation to meet Code level 4 has been identified as predominantly, incremental, exploring combinations of existing established and recent products and processes to achieve the required CO_2 emission reduction.

This finding serves to confirm the predominant view of literature that characterises construction innovation as incremental in spite of the stretching targets of achieving a 100% CO_2 reduction target from 2015. Specifically, the features of the innovative response to the Code reflect Schumpeter's classic definition of innovation as 'new combinations of existing resources' (noted in Chapter Two, Section 2.3).

Five: The innovative process in response to multiple design requirements and constraints is characterised by four distinct yet overlapping elements of iteration, negotiation, compromise and solution.

Analysis for Research Question Two identified the process of innovation in response to regulation as dynamic and shared, in which elements of iteration, negotiation, compromise and solution are recognised. Collaborative negotiation between regulating and complying organisations is noted (Kemp, 2000; Winch, 1998 - Chapter Two, Section 2.13.2) and the identification of negotiation as part of an innovative process of compliance extends this knowledge.

5.6 Further research

Having completed this research, potential subject areas that would extend, and refine and (to some extent) test the research findings are noted.

5.6.1 The early project phase

The early stage project is a valid subject for study in its own right, rather than as a prelude to the significant body of construction project management research (Kolltveit & Grønhaug 2004). At this stage the regulatory organisations, who have no contractual obligations to the project, can significantly alter the given environment, and the commercial organisations are subjected to financial risk and uncertainty.

5.6.2 Iteration, negotiation, compromise and solution

The account of the innovative process in response to regulation for the Smith Lane early development was described using four terms; iteration, negotiation, compromise and solution. The four terms are in common use and may carry ‘baggage’ and the development of research to further explore and substantiate their use, both individually and collectively, would draw together and extend elements identified in the literature review of

negotiation as a response to regulation noted by, for example, Winch (1998).

5.7 Code for Sustainable Homes - postscript

At the start of the research, the Code for Sustainable Homes had been recently introduced as a voluntary sustainability accreditation for new housing, as part of the broader policy objective for the housing construction sector to build more, better and cheaper housing to address the housing shortage, within a reasonably healthy economy and buoyant housing market. Following on from EcoHomes, meeting the Code at level 3 was mandatory for social housing developments in receipt of National Affordable Homes Programme (NAHP) funding, and a consultation on making the Code obligatory for all new homes was carried out.

However, the impact of the subsequent housing market collapse of 2007 continues to both depress the volume of new housing (where annual housing completions, in September 2011, are at 40% below the recent peak of 2006 (DCLG 2011:2)), and increase the relative cost of construction and price of purchase within a 'credit crunch' context. The focus of policy drivers for addressing sustainability, and in particular CO_2 reduction, have been shifted to supporting the retrofit of existing housing, the HCA maintained its requirement for Code level 3 for its 2012 – 2015 funding programme (rather than increasing this to level 4 as had been anticipated) and the Code remains a voluntary standard. The mandatory phased reduction of CO_2 emissions to zero (equivalent to the level specified for a Code 5 home) from 2015 has been incorporated into the framework for the continual review of Building Regulations.

The profile of the Code in current academic literature is assessed as muted. It continues to be cited as a comparative example at an international level as a policy driver for increasing sustainability of housing and reducing CO_2 emissions (e.g. Yu & Kim, 2011) however, detailed UK

academic analysis finds that the Code is unlikely to achieve its policy goals because there is a lack of clarity on the overall reduction target for all greenhouse gas emissions (Saunderson et al, 2008) and a lack of knowledge of how relevant technologies operate in 'real world' situations (e.g. MacManus et al, 2010). Analysis of the role of occupant behaviour on performance of high Code-rated homes is prevalent (e.g. Gill et al, 2010 in a Building Research and Information special issue on housing occupancy feedback linking behaviours and performance), finding that occupant understanding of Code social housing is low and recommending that investment in changing behaviour is urgently needed to achieve and maintain CO_2 reduction (Pilkington et al, 2011).

The volume of private and local authority and housing association publicly funded Code housing as a proportion of all new housing since the introduction of comprehensive monitoring is captured in the charts below (DCLG, 2011a and DCLG, 2011b). In total, 43,808 completion stage Code certificates have been issued up to June 2011, representing around 16% of all completed homes during the same timescale. Of these, 85% are public and 15% private. Figure 5.1 charts the volume of private and publicly funded Code housing as a proportion of all housing, clearly showing the increase in public Code housing for the two years to March 2011.

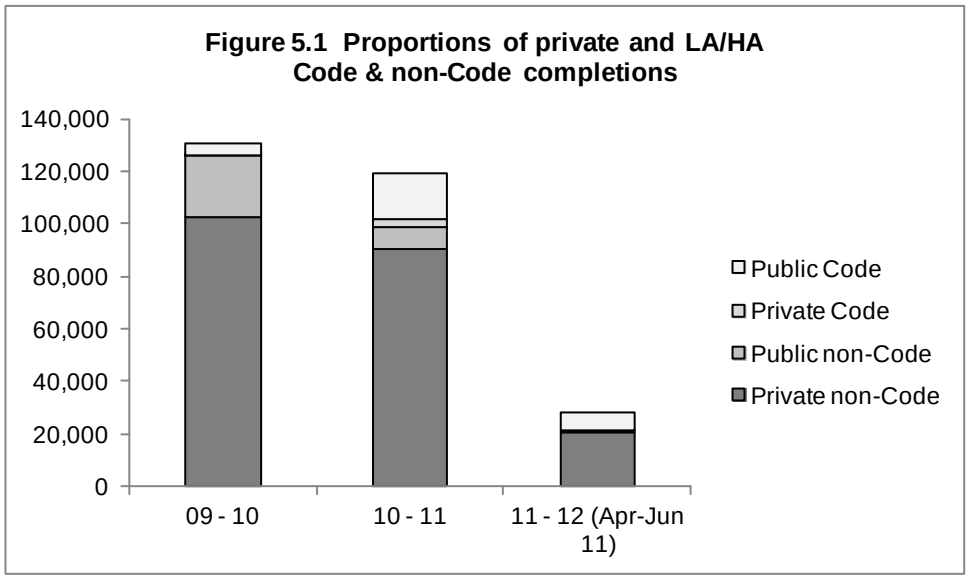


Figure 5.1 Proportions of private and LA/HA Code and non-Code completions over time.

Within both public and private Code totals in Figure 5.1 since 2009, the majority (89% and 86% respectively) are Code 3. Figures 5.2 and 5.3 capture the small numbers of higher Code level completions over time for both public and private housing, showing its increasing success as a mandatory standard for innovative public funded housing and that its traction as a voluntary standard for innovation in exemplar private sustainable housing continues to be limited.

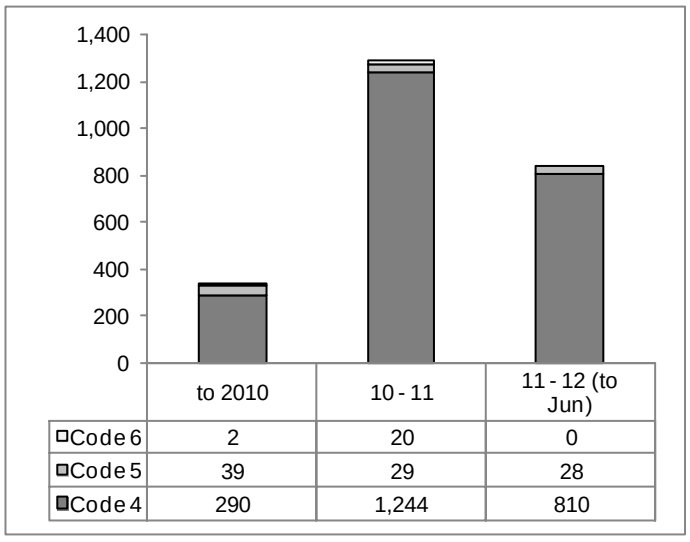
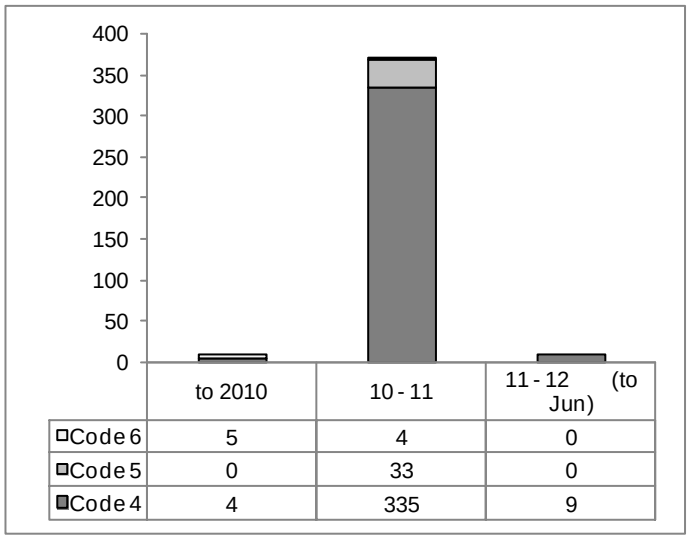


Figure 5.2 Numbers of LA & HA higher Code completions over time



	to 2010	10 - 11	11 - 12 (to Jun)
Code 6	5	4	0
Code 5	0	33	0
Code 4	4	335	9

Figure 5.3 Numbers of private higher Code completions over time

Thus the Code for Sustainable Homes, as a new regulation, is accommodated within both broad academic literature on construction management and current housing design and construction practice, and can be assessed as being successful to some extent. Any shortcomings are now available for academic and practitioner scrutiny based on empirical evidence.

5.8 Final paragraph

Finally, to answer the question expressed in the thesis title 'The Code for Sustainable Homes; what are the innovation implications for the social housing development sector?' this research finds that Code level 4 can be achieved with an innovative combination of existing building techniques and recent energy generating technologies, identified as incremental innovation. However, within the early project phase of the design of Code 4 housing, innovation is also identified in the response to multiple and often conflicting additional regulatory requirements of project team members, including the Code, resolved through a shared process of iteration, negotiation, compromise and solution.

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