Birmingham Places of the Future SPD

Technical Note: Viability Assessment of Policies SP5, SP7 & SP8

Birmingham City Council

November 2011

Plan Design Enable

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This document has 45 pages including the cover.

Document history

Job number: 5103060			Document ref: Technical Note: Viability Assessment of Policies SP5, SP7 & SP8			
Revision	Purpose description	Originated	Checked	Reviewed	Authorised	Date
Rev 1.0	<purpose>	<ED>	<PS>	<RA>	<RS>	27/10/11

Client signoff

Client	Birmingham City Council
Project	Birmingham Places of the Future SPD
Document title	Technical Note
Job no.	5103060
Copy no.	
Document reference	Technical Note: Viability Assessment of Policies SP5, SP7 & SP8

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1. Introduction

1.1 The purpose of this Technical note is to provide an assessment of feasibility and viability of the Draft Core Strategy policies relating to the Places for the Future Supplementary Planning Document (SPD), specifically SP5, SP7 and SP8. This adds to the evidence base underpinning these policies.

1.2 The note involves recommendations and advice on how the Draft policies may be further strengthened. The key issues which are explored are:

- Consideration of which Code for Sustainable Homes level (CfSH) can be achieved in different housing market areas;
- Viability of low and zero carbon technologies, including Combined Heat and Power (CHP); and
- Future prospects for securing Codes and higher carbon emissions reductions.

1.3 The technical note will explore testing the feasibility and viability of compliance with the Council's policy requirements. This is assessed across six case studies that offer a range of size and residential development type. A sensitivity analysis is conducted to test the maximum CfSH compliance based on selection of renewable energy technologies and the estimated costs to comply with other parts of the code based on Communities and Local Government's report 'Cost of building to the Code for Sustainable Homes: Updated cost review' prepared by Element Energy and Davis Langdon in August, 2011.

Methodology

1.4 The methodology adopted to assess the viability of subsequent stages of Code for Sustainable Homes is described in Figure 1-1 and further detailed into the following sections.

1.5 Local policies on introducing low and zero carbon technology should have regard of the key requirements of the Planning Policy Statements at the national level and demonstrate that these requirements are being met. PPS1 Supplement requires that new development has an evidence based understanding of local feasibility and the potential for renewable and low carbon technologies. Moreover, the council should set a target of energy use for new developments that must come from decentralised and renewable or low energy sources, where it is viable.

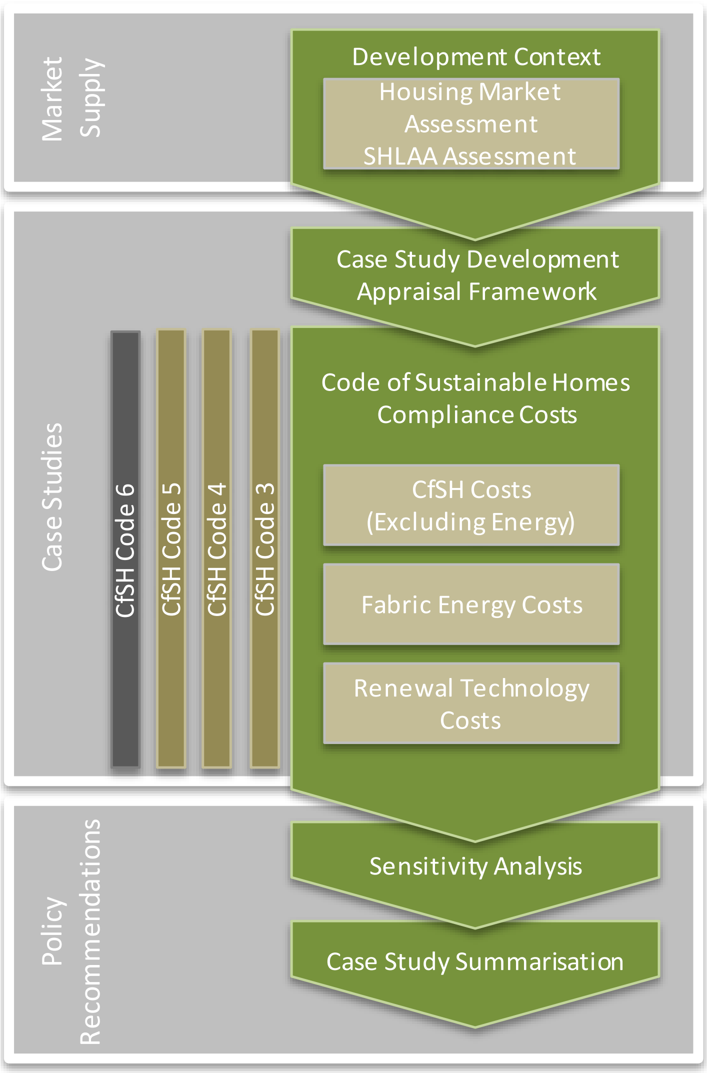
1.6 Where there are particular and demonstrable opportunities for greater use of the above, policies should aim to bring forward development, as well as indentify the size and type of development to which the energy targets will be applied. This must be based on a clear rational and must be properly tested and proven.

1.7 National planning policy states that areas suitable for renewable and low zero carbon energy sources should be considered and identified, with regards to supporting infrastructure. Similarly, attention must be made to existing and potential decentralised, renewable or low zero carbon sources, and potential for co-heating customers and suppliers and future connections.

1.8 The evidence base work must include a viability assessment component and have regard to overall site development costs. The approach is consistent with securing the supply and pace of housing and not inhibiting the provision of affordable housing. The council should attempt to advise potential developers on the implementation of the requirements set forth through monitoring and enforcement which is a focus for the Places of the Future SPD.

1.9 PPS 22 advises local authorities to allow alternative sources of renewable or low zero carbon sources, and not let policy limit developers to one or few technologies. The objective of this guidance is to ensure the development of dwellings meets the respective carbon emissions requirements, but not limit or hinder residential development or compromise reduction targets.

Figure 1-1: Carbon Viability Assessment



Development Context:

1.10 A Housing Market Assessment of the city has been conducted, linked to Birmingham's Affordable Housing Viability Study prepared by Entec for the council in October 2010. On the supply side the BCC Strategic Housing Land Availability Assessment (SHLAA April, 2010) database provides details of the portfolio of affordable housing sites with potential to accommodate residential developments. These evidence base documents provide details of housing land supply and housing market conditions within which carbon emissions reduction targets, CfSH and other policy requirements can be considered. The Affordable Housing Viability Study was used to segregate the Birmingham market into "Hot", "Moderate" and "Cold" market based on the house prices of different market areas.

Case Studies:

1.11 Based on the affordable housing sites, six case studies were defined through discussions with the council which are representative of the size and types of sites in the pipeline of potential housing sites. Development appraisals of the case studies were prepared, based on benchmarked sales prices identified in the Affordable Housing Viability Study.

1.12 The Code for Sustainable Homes requirements were separated into non-energy compliance costs and energy costs. The energy costs were further categorised into fabric energy compliance and cost of renewal technologies adopted, in order to identify the impact on viability of individual technologies. Sensitivity testing was undertaken to consider the impact of the costs of compliance on viability and on the overall supply and pace of housing delivery.

1.13 This considered Code 3, Code 4, Code 5 minimum compliance and Code 5 Zero carbon compliance[1]. Where Code 5 Zero Carbon targets were not met, allowable solutions were considered at £100 carbon / tonne and added to the costs.

1.14 A summary of findings has been included in the viability section of this report and used to derive policy recommendations. We have also taken a forward look at the likely viability of CfSH 4, CfSH 5 and CfSH 5 Zero Carbon, for when they are proposed to be introduced at national level.

[1] Code 5 Zero Carbon has replaced Code 6 as the new target for Zero Carbon emissions by 2016.

2. Market Assessment

2.1 This section introduces the rationale behind the selection of the development appraisals case studies and is based on an understanding of the Birmingham housing market. The choice of case studies are consistent with the analysis of the Birmingham City market in line with Birmingham's Affordable Housing Viability Study prepared in October 2010 and the BCC Strategic Housing Land Availability Assessment (SHLAA April, 2010) database.

Market and Supply

2.2 The BCC Strategic Housing Land Availability Assessment (SHLAA) database was used to analyse the quantum of potential supply of land for housing. The supply was split into sizes based on the capability to incorporate low and zero carbon technology within the project. In line with discussions with BCC, the potential supply of housing projects has been categorized into 1-15 units, 15-50 units (the threshold for requiring CHP provisions), 50-300 units and over 300 units (the threshold triggering affordable housing requirement). This tested the proposed thresholds for affordable housing provision and for on-site provision of CHP.

2.3 The Entec Affordable Housing Viability Study (October, 2010) has been used to provide assumptions relating to housing revenues in the city and other development appraisal assumptions to provide a common basis of comparison. The study divides the BCC market into ten Housing Market Areas (HMAs) based on their prices and ability to include affordable housing. For the purpose of this study, the HMAs have been further clustered into "hot", "moderate" and "cold" based on their price points.

2.4 By combining the findings of the SHLAA database and the HMA markets, a summary of supply by HMA is presented in Table 2-1 below. The table shows that across all three market areas there is a similar pattern of site sizes with 1-15 units constituting the majority of supply (66-71%) and above 300 units having the smallest contribution (1-3%).

Table 2-1: SHLAA sites distributed by housing market areas

Market	Range	No. Sites	%
HOT (HMA 1-4)	1-15 Units	348	71%
	15-50 Units	80	16%
	50-300 Units	56	11%
	>300 Units	3	1%
Total		487	100%

Market	Range	No. Sites	%
MODERATE (HMA 5-7)	1-15 Units	371	69%
	15-50 Units	80	15%
	50-300 Units	74	14%
	>300 Units	10	2%
Total		535	100%

Market	Range	No. Sites	%
COLD (HMA 8-10)	1-15 Units	253	66%
	15-50 Units	52	13%
	50-300 Units	70	18%
	>300 Units	11	3%
	Total	386	100%

2.5 However as seen in Table 2-2, while the number of sites in the 1-15 unit range form a majority of the sites in Birmingham they constitute only 10% of the potential supply of residential units in Birmingham. Over 75% of the estimated supply of units are on sites that have potential for 50 units and above (i.e. 47% for 50-300 units and 30% in more than 300 units).

Table 2-2: Strategic Housing Assessment by number of units supplied

Range	No. Sites	%	Units	%
1-15 Units	868	62%	4,447	10%
15-50 Units	316	22%	6,027	13%
50-300 Units	200	14%	21,704	47%
>300 Units	24	2%	13,991	30%
Total	1,408	100%	46,169	100%

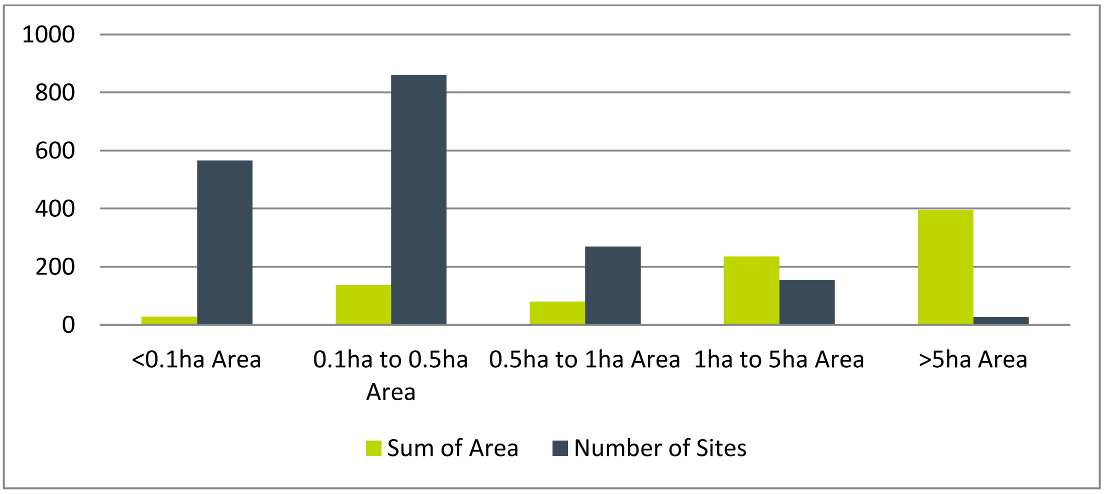
2.6 In addition to size, the density of development is important in determining the type of renewable technologies adopted within a project due to economies of scale. As seen in Table 2-3 a majority of the sites (59%) have a potential gross density below 50 units per hectare. Projects with density of over 80 units / ha (27% of the sites) are concentrated primarily in the two wards of Ladywood and Nechelles as seen in Appendix A Figure A-1.

Table 2-3: Strategic Housing Assessment by density

	Density <50 Units / Ha		Density 50-80 Units / Ha		Density >80 Units / Ha	
Distribution	59%		14%		27%	
	No. Sites	%	No. Sites	%	No. Sites	%
1-15 Units	543	79%	95	61%	122	38%
15-50 Units	83	12%	33	21%	69	22%
50-300 Units	51	7%	26	17%	114	36%
>300 Units	8	1%	3	2%	12	4%
	685	100%	157	100%	317	100%

2.7 The highest concentrations of sites are sized between 0.1 and 0.5 ha. However the sum of all the sites is far less significant in terms of land supply. The concentration of smaller sites below 1 ha in size, may result in a reduced capability for some on-site low and zero carbon technologies.

Figure 2-1: SHLAA sites by site size



3. Viability testing

Approach

3.1 PPS1 Supplement requires that local targets are formulated on the basis of evidence of local feasibility and potential for renewable and low carbon technologies. Any targets set by the Council should also be evidence based and viable, having regard to overall site development costs. The approach should be consistent with securing the supply and pace of housing and not inhibit the provision of affordable housing.

3.2 This chapter considers these issues by testing the costs of the requirements of policies SP5, SP7 and SP8 and having regard to the range of possible technological solutions, which may be deployed including on site solutions and local energy networks.

3.3 To test the impact of the Draft policies on viability there is a need to consider the cost of low and zero carbon technology options in the context of other site development costs in the city. This has been carried out using a number of development appraisal case studies, which are representative of sites in the Council's development pipeline.

Development Appraisal Framework and Assumptions

3.4 The development appraisal framework has been prepared to be consistent with other studies being undertaken by the Council, including affordable housing and market assumptions set out in the Entec Affordable Housing Viability Study (October, 2010). The case studies were simulated in areas with varying market conditions. As identified above, the markets have been segregated into "hot", "moderate" and "cold" areas, and were each assigned an associated level of affordable housing provision as set out below.

Table 3-1: Affordable Housing Provision in Different Locations

Market Condition	Areas	Affordable Housing Provision
Cold	HMA 8, HMA 9, HMA 10	20%
Moderate	HMA 5, HMA 6, HMA 7	20%
Hot	HMA 1, HMA 2, HMA 3, HMA 4	35%

3.5 The location of the case study is a key influence on viability as it informs the potential development value produced and the related level of affordable housing which may be secured. The CS6 case study considers the location of prominent regeneration brownfield sites and greenfield site at the edge of the urban area.

Construction Costs

3.6 The construction costs used in the viability model were taken from the Building Cost Information Service (BCIS). The BCIS provides a range of costs per square metre (sqm) for the different housing typologies portrayed in the case studies, e.g. flats and housing (terraced). Therefore the type of housing constructed would also have an effect on the viability of a case study. The construction cost rates are identified in the tables below.

Table 3-2: Residential Construction Cost Rates

Residential Construction		BCIS based on GIA. Residential GIA = 90% of GEA
BCIS rate flats:	£801 /sqm	BCIS: West Midlands Region - Median Construction Cost; General Flats, 3rd Quarter 2011
BCIS rate Housing (terraced)	£696 /sqm	BCIS: West Midlands Region - Median Construction Cost; 2 storey terraced Houses, 3rd Quarter 2011

3.7 The costs used in the viability model were adjusted to reflect the costs in the West-Midlands region, during the third quarter of 2011. Furthermore, floorspace figures for the case studies were provided as gross internal areas (GIA), which are directly applied to sales revenues. However, costs must be applied to the gross external area (GEA) in order to portray the cost of the entire development. As such, the consultant has assumed the residential GIA floorspaces to be 90% of their GEA.

Relationship with Code for Sustainable Homes

3.8 The Construction costs in the case studies were adjusted to also reflect the costs associated with the Code for Sustainable Homes. The case studies were tested for compliance to Level 3, Level 4, Level 5 minimum compliance and level 5 zero carbon (equivalent: as per the new definition). In addition, the model tests compliance for zero carbon compliance of CfSH Level 6 which is the original definition of zero carbon homes.

3.9 Information on the costs associated with Code for Sustainable Homes have been drawn from the Communities and Local Government's report 'Cost of building to the Code for Sustainable Homes: Updated cost review' prepared by Element Energy and Davis Langdon in August, 2011. This document provided cost estimates associated with different dwellings types for each level of the code. Table 3-4 provides a summary of the overall costs of Code for Sustainable Homes as per the updated cost review (not including energy costs). The construction and infrastructure costs in the code not linked to renewables energy were separated from these assumptions to avoid double counting and to enable the modelling of costs specific to the Council's policies.

3.10 The cost review figures in Table 3-4 is based upon the updated cost review and includes the non-energy costs for compliance include efficiency measures for water, materials, surface, waste, pollution, health, management and ecology. For the purpose of the viability appraisal, the consultants have assumed the costs for implementation of the CfSH for "small brownfield" costs would be primarily applicable to projects below 15 units and "edge of town" costs for 15-50 units. For projects larger than 50 units we have assumed an average of "edge of town and urban regeneration" costs based on the distribution of sites in the SHLAA database. The costs per square metre were used as additional costs to the residential constructions of each case study in order to derive a realistic assessment of viability.

3.11 The energy costs were further divided between fabric energy costs and the cost for renewal energy technologies and have been described further in Appendix B. The low and zero carbon technologies were tested for Solar thermal / Photovoltaic and CHP to assess the viability of adopting these technologies within a project. These generally represent the highest and lowest cost alternatives for on-site low and zero carbon technologies and so embrace the range of costs for any given technology mix.

Table 3-3: Costs of implementing Code for Sustainable Homes
(not including Energy Building Fabric costs)

Small Brownfield

	2 Bed Flat £/ Unit	Flat Average Size 61 m2	Terrace £/ Unit	House Average Size 73 m2	Semi-House £/ Unit	House Average Size 88 m2
Code 1	£203 / Unit	£3 / m2	£290 / Unit	£4 / m2	£290 / Unit	£3 / m2
Code 2	£403 / Unit	£7 / m2	£440 / Unit	£6 / m2	£440 / Unit	£5 / m2
Code 3	£678 / Unit	£11 / m2	£652 / Unit	£9 / m2	£1040 / Unit	£12 / m2
Code 4	£678 / Unit	£11 / m2	£1040 / Unit	£14 / m2	£1190 / Unit	£14 / m2
Code 5	£8188 / Unit	£134 / m2	£7245 / Unit	£99 / m2	£7325 / Unit	£83 / m2
Code 6	£8188 / Unit	£134 / m2	£7245 / Unit	£99 / m2	£7325 / Unit	£83 / m2

Edge of Town

	2 Bed Flat £/ Unit	Flat Average Size 61 m2	Terrace £/ Unit	House Average Size 73 m2	Semi-House £/ Unit	House Average Size 88 m2
Code 1	£203	£3 / m2	£290	£4 / m2	£290	£4 / m2
Code 2	£403	£7 / m2	£440	£6 / m2	£440	£6 / m2
Code 3	£1,222	£20 / m2	£1,318	£18 / m2	£1,468	£20 / m2
Code 4	£1,772	£29 / m2	£1,818	£25 / m2	£1,968	£27 / m2
Code 5	£8,732	£143 / m2	£7,723	£106 / m2	£7,803	£107 / m2
Code 6	£13,712	£225 / m2	£7,723	£106 / m2	£7,803	£107 / m2

Average of Edge of Town and Urban Regeneration

	2 Bed Flat £/ Unit	Flat Average Size 61 m2	Terrace £/ Unit	House Average Size 85.0 m2	Semi-House £/ Unit	House Average Size 85.0 m2
Code 1	£203	£3 / m2	£290	£4 / m2	£290	£4 / m2
Code 2	£403	£7 / m2	£440	£6 / m2	£440	£6 / m2
Code 3	£956	£16 / m2	£977	£13 / m2	£1,152	£16 / m2
Code 4	£1,456	£24 / m2	£1,277	£17 / m2	£1,427	£20 / m2
Code 5	£8,086	£133 / m2	£7,344	£101 / m2	£7,432	£102 / m2
Code 6	£10,866	£178 / m2	£7,344	£101 / m2	£7,432	£102 / m2

Planning Obligations Assumptions

3.12 The Planning Obligation assumptions made in the consultant's model are drawn from the Entec Affordable Housing Viability Study (October, 2010). The costs associated with the Planning Obligation requirements above vary by location and, where applicable, they are calculated on an occupancy per unit basis.

3.13 For affordable housing, different assumptions were established for case studies based on their locations with respect to the housing market areas. Some locations were considered to have better market conditions than others, and were identified as being "hot" areas. As these areas have a greater potential of producing higher returns, their affordable housing is set to optimise the delivery of affordable housing, consistent with the Council's Core Strategy targets. Affordable housing provision for each area type is shown in Table 3-1 above.

Other costs

3.14 Other costs relating to land purchase and fees have been incorporated into the model. These are identified in Appendix C.

Case Studies

3.15 To consider the effect of the increased development costs associated with the Councl's Core Strategy policies, six case studies representative of the range of different residential developments within the Councils housing supply trajectory were identified. They were tested to consider the marginal and overall effect of the potential costs associated with different policy thresholds and their effect on the viability of development and housing delivery. The case study results are indicative of other similar sized developments which may come forward in the city. The costs considered include CfSH requirements and the requirements of Policy SP8.

3.16 The case studies vary in terms of the type and scale of development to illustrate the effects of policy targets in different contexts in the City. Based on the supply analysis (as described above). As seen in Table 3-5, the case studies are summarised below:

- **CS1 & CS2:** Consist of sizes of 1-15 units in both apartments (CS1) and houses (CS2). This category constitutes 62% of the number of sites supplied in the City. The Apartments of 1 bed, 2 bed and 3 bed while houses are 2 bed and 3 bed. This size category constitutes more than 60% of the site supply within the city. CS1 and CS2 were assumed to be "small brownfield" projects for the purpose of CfSH costs.
- **CS3 & CS4:** Consist of sizes of 15-50 units typically, for apartments (CS3), and houses (CS4). Although this case study category constitutes a smaller supply of residential units for Birmingham (13%), it is 22% of the total number of projects and serves as the most challenging in carbon viability. CS3 and CS4 were assumed to be "edge of town" projects for the purpose of CfSH costs.
- **CS5:** Consists of mixed development of apartments and houses between 50-300 units (i.e. 200 units). This constitutes the largest estimated supply of residential units for Birmingham (47%) although it is only 14% of the total supply of sites. For the purpose determining CfSH costs of CS5 was assumed to be combination of "urban regeneration and edge of town" projects.
- **CS6:** Consists of a typical larger mixed residential use development above 300 units (i.e. 500 units). Although this case study typically reflects only 2% of the projects in entering the market, it is the second largest supply of residential units for Birmingham (30%). Similar to CS5, CS6 was assumed to be a combination of "urban regeneration and edge of town" projects.

3.17 The details of individual case studies are as set out in Table 3-5 below:

Table 3-4: Generic Case Studies

	Apartment			House		
Viability Case Study	1 bed	2 bed	3+ bed	2 bed	3+ bed	Total
CS1	4 Units	5 Units	6 Units			**15 Units**
	300 m2	425 m2	630 m2			1,355 m2
CS2				7 Units	8 Units	**15 Units**
				770 m2	1,000 m2	1,770 m2
CS3	15 Units	15 Units	20 Units			**50 Units**
	1,125 m2	1,275 m2	2,100 m2			4,500 m2
CS4				25 Units	25 Units	**50 Units**
				2,750 m2	3,125 m2	5,875 m2
CS5	35 Units	40 Units	40 Units	40 Units	45 Units	**200 Units**
	2,625 m2	3,400 m2	4,200 m2	4,400 m2	5,625 m2	20,250 m2
CS6	75 Units	100 Units	125 Units	100 Units	100 Units	**500 Units**
	5,625 m2	8,500 m2	13,125 m2	11,000 m2	12,500 m2	56,450 m2

3.18 Each case study was tested across “hot”, “moderate” and “cold” market scenarios and the applicable affordable housing requirements (i.e. between 20% and 35%). The appraisal showed that scheme returns varied significantly between the case studies. In some cases in current market conditions schemes were identified as not being viable or being marginally viable without considering the additional marginal development costs associated with SP5, SP7 and SP8 policy targets. In these situations the future improvement in market circumstances was modelled to identify where targets may be achievable later in the plan period.

3.19 The Places for the Future SPD sets out the approach to implementing these policies.

Low and Zero Carbon (LZC) Technology Costs

3.20 The costs for each LZC technology which were applied and drawn from the tables included within Appendix C, which relate to industry benchmarks.

3.21 For the purpose of sensitivity testing, the consultant has modelled the range of potential technology costs, based on the more expensive LZC technologies (i.e. Photovoltaic) and CHP (on-site / scheme-wide and city-wide) in line with Birmingham’s Core Strategy policy SP8 and the targets of CfSH. Should technologies be combined then costs will lie within the limits of the renewables costs identified.

3.22 The viability of local or area wide energy network proposals was considered separately for the three of the case studies where these were identified as feasible options. The following section highlights the differences the identified technologies have on the viability of the development appraisal case studies.

On Site Options

3.23 For each of the development typologies, Appendix C shows the range of cost assumptions. The two indicators (the cost per dwelling unit and the cost per sq.m) provide a basis of comparing costs between different development typologies and policy targets.

3.24 In general, for all technologies the cost per sqm and the cost per unit gradually decrease as the size of the development increases. However, there is no clearly quantifiable reduction for economies of scale which may differ from project to project, depending on the details of the scheme, hence the consultants have assumed a flat rate for all scales of projects.

Current and Future Viability

3.25 The additional costs of the Fabric energy standard and the additional LZC technologies required to meet CfSH targets were added to the outputs of the viability appraisal of each case study, in order to derive the impact the policies would have on the viability of each case study.

3.26 Table 3-5 below shows the initial returns of the individual case studies in the varying market conditions, with Part L of the 2010 Building Construction regulations meeting with Code 3 compliance and without the added costs of individual LZC technologies. For the purpose of this exercise, it has been assumed that a developer's return must be above 20% for a scheme to be viable.

Table 3-5: Initial Developer's Returns in varying Market Conditions (Code 3 Compliance)

	HOT		MODERATE		COLD	
Case Study	Scheme Viability	Developer's Return	Scheme Viability	Developer's Return	Scheme Viability	Developer's Return
CS1	YES	23%	NO	11%	NO	-2%
CS2	YES	29%	NO	17%	NO	3%
CS3	YES	29%	NO	17%	NO	3%
CS4	YES	39%	YES	25%	NO	11%
CS5	YES	34%	YES	21%	NO	8%
CS6	YES	37%	YES	24%	NO	10%

3.27 The above table reveals that all case studies should normally be viable when constructed in accordance to Code 3 compliance and in a favourable "Hot" market. Exceptions may occur where there are other abnormal development costs. In a "Moderate" market area, case studies 1 and 2 become unviable. Case Study 3 is also unviable in a "Moderate" market climate. This is also due to the reduction in revenues, but moreover, as Case Study 3 comprises of only apartment developments, it is subject to comparatively higher construction costs, according to the BCIS database, and the sales values of the units are lower than those achievable for houses. The same is true for Case Study 1, which also only comprises of apartments. The remainder of the case studies are viable in a "Moderate" market.

3.28 In a "Cold" market, none of the schemes are viable at this initial stage. This is due solely to the significant low sales values of developments in "Cold" markets, and the effect of the 20% affordable housing policy.

3.29 The following section will examine the viability of the case studies in different market conditions, once additional LZC technologies have been added on to meet the requirements of Policy SP8 and higher levels of the Code.

Case Study 1

3.30 Table 3-6 below shows the effects on the viability of Case Study 1 under varying market areas, when the scheme includes additional renewable technologies and the construction costs necessary to meet the requirements for different levels of the CfSH.

Table 3-6: Case Study 1: 2011 Viability Outcomes

	Case Study 1		
	Hot	Moderate	Cold
CfSH3	22.9%	10.6%	-1.9%
CfSH3 + connected CHP	19.0%	6.7%	-5.7%
CfSH4	22.8%	10.5%	-1.9%
CfSH4 + connected CHP	19.0%	6.7%	-5.8%
CFSH4 + PV and Solar	7.6%	-4.6%	-17.1%
CfSH5	12.9%	1.6%	-9.9%
CfSH5 + connected CHP	9.3%	-1.9%	-13.4%
CfSH5 + connected CHP + Allowable Solution to Reach Zero Carbon	8.1%	-3.2%	-14.7%
CfSH5 + PV and Solar	-1.1%	-12.3%	-23.9%

3.31 In a “Hot” market area, Case Study 1 provides a developer’s return of 22.9%, approximately 3% above the viability threshold set for this study. As such, the developer’s margin is close to the point of viability. The simulation reveals that the scheme can be viable, in a “Hot” market, if the development is constructed to meet Code 4 requirements.

3.32 The introduction of a city wide CHP connection would be marginally viable for the scheme, under the delivery of non-energy components meeting Code 3 and Code 4 requirements, with returns that are 1% from of the viability threshold. Case Study 1 is unviable in all other scenarios tested.

3.33 The viability outcomes shown in Table 3-6 above are relevant to existing levels of sales and costs. An exercise was conducted to determine the projected viability of the case studies at the stages of when development is expected to meet the subsequent requirements of Code 4 and Code 5; 2013 and 2016, respectively. The effects on case study viability, from adding renewable technologies, were assessed at these future stages to determine whether schemes could be viable in the future as well as reach carbon emission reduction targets.

3.34 The findings show that the developer’s returns from Case Study 1 are marginally above the viability threshold in the “Hot” market areas only. This is primarily due to the scheme comprising of solely apartments, which require higher construction costs and lower sales values. In addition to this, the simulation for the scheme factors in a 35% affordable housing component in a “Hot” market, and a 20% affordable housing provision in both the “Moderate” and “Cold” market. Therefore the viability of Case Study 1 was examined without an affordable housing contribution.

3.35 The results show that in a “Hot” market without the provision of affordable housing, the scheme is viable with the inclusion of all renewable energy options and meeting the regulations of CfSH 3, CfSH 4 and CfSH 5. A “Moderate” market would also enable a developer to construct the scheme to the building regulations of Code 3 and Code 4. The results are shown in the table below.

Table 3-7: Case Study 1 (0% Affordable Housing): 2011 Viability Outcomes

Case Study 1 (0% Affordable Housing)	Hot	Moderate	Cold
CfSH3	48.8%	21.1%	6.5%
CfSH3 + connected CHP	45.0%	17.4%	2.7%
CfSH4	48.7%	21.1%	6.5%
CfSH4 + connected CHP	44.9%	17.3%	2.6%
CfSH4 + PV and Solar	33.8%	6.1%	-8.6%
CfSH5	36.8%	11.4%	-2.1%
CfSH5 + connected CHP	33.4%	7.9%	-5.6%
CfSH5 + connected CHP + Allowable Solution to Reach Zero Carbon	32.8%	7.3%	-6.2%
CfSH5 + PV and Solar	23.1%	-2.4%	-16.0%

3.36 The findings on the projected viability of Case Study 1in **2013** and **2016** are listed below:

- In 2013, when development is required to meet Code 4, Case Study 1 is viable with a city wide CHP connection, at a return of 22.4%.
- With a city wide CHP connection, the scheme exceeds its carbon emission reduction target by over 7,200 kg/ CO2 per annum.
- Although PV and Solar Thermal technology exceed the emissions target by over 33,600 kg/ CO2, the increasing cost mean returns are at 11.5% and not viable.
- All other scenarios in 2013 are unviable for Case Study 1.
- In 2016, when development is required to meet Code 5, Case Study 1 is just viable at 20.4% developer returns meeting code requirements (but achieves this through fabric energy application and renewal technology options shall be limited by viability). Despite sales values projected to increase at a rate greater than construction costs[2], the sharp increase of non-energy compliance costs[3] between Code 4 and Code 5 (from £11/ sq. m. to £134/ sq. m.) greatly deteriorate the initial viability of the scheme.
- All other scenarios in 2016 are unviable for Case Study 1.

Case Study 2

3.37 Table 3-8 below shows the effects on the viability of Case Study 2 in different market areas, in accordance to additional renewable technologies and construction costs related to the different CfSH levels.

[2] Projections based on BCIS cost projections and CLG sales Projections
[3] Non-energy CfSH compliance costs from "Cost of building to the Code for Sustainable Homes: Updated cost review"

Table 3-8: Case Study 2: 2011 Viability Outcomes

Case Study 2	Hot	Moderate	Cold
CfSH3	29.0%	16.6%	3.4%
CfSH3 + connected CHP	24.9%	12.2%	-1.1%
CfSH4	27.8%	15.6%	2.5%
CfSH4 + connected CHP	23.5%	11.3%	-1.9%
CFSH4 + PV and Solar	19.3%	7.1%	-6.0%
CfSH5	20.9%	9.4%	-3.1%
CfSH5 + connected CHP	16.8%	5.2%	-7.2%
CfSH5 + connected CHP + Allowable Solution to Reach Zero Carbon	15.8%	4.3%	-8.1%
CfSH5 + PV and Solar	12.9%	1.3%	-11.1%
CfSH5 + PV and Solar + Allowable Solution to Reach Zero Carbon	11.5%	0.0%	-12.5%

3.38 In a "Hot" market, Case Study 2 provides an initial developer's return of 29.0%, allowing a sufficient margin to deliver additional renewable technologies and the construction costs required to meet higher CfSH levels. The simulation reveals that in a "Hot" market the scheme can still stand as viable to meet the energy and non-energy construction costs required for Code 5.

3.39 Code 3 and Code 4 are still viable if they were to accommodate city wide CHP connection, while at Code 5, the scheme is able to comply to fabric energy requirements but may not be viable with the addition costs renewal energy technology. The scheme can also deliver the PV and Solar Thermal technology along with Code 4 Building Construction regulations at approximately 19.3% developer's return, which is just below the viability threshold. Case Study 2 is unviable in all other scenarios tested.

3.40 The 15 units in Case Study 2 did not provide the critical scheme size to produce sufficient returns, that would allow a developer to deliver renewable energy technology beyond meeting the building regulations for Code 4. This case study was therefore also tested with no affordable housing.

3.41 The findings show that the scheme would produce relatively higher returns for a developer, especially in a "Hot" market wherein all scenarios are viable; the most expensive option (CfSH 5 + PV and Solar Thermal technology + Allowable Solution to reach Zero Carbon) delivering a return of 39.8%.

3.42 A "Moderate" market, would allow a city wide CHP connection with Code 3and Code 4. The provision of PV and Solar Thermal technology with Code 4 is marginally unviable, with a return of 19.3%. A "Moderate" market would also enable the developer to construct the scheme to the building regulations of Code 5. The results are shown in the table below.

Table 3-9: Case Study 2 (0% Affordable Housing): 2011 Viability Outcomes

Case Study 2 (0% Affordable Housing)	Hot	Moderate	Cold
CfSH3	58.0%	28.8%	13.2%
CfSH3 + connected CHP	53.7%	24.4%	8.9%
CfSH4	56.7%	27.6%	12.2%
CfSH4 + connected CHP	52.4%	23.3%	7.9%
CfSH4 + PV and Solar	48.3%	19.3%	3.8%
CfSH5	48.3%	20.8%	6.2%
CfSH5 + connected CHP	44.3%	16.7%	2.1%
CfSH5 + connected CHP + Allowable Solution to Reach Zero Carbon	43.8%	16.3%	1.6%
CfSH5 + PV and Solar	40.5%	12.9%	-1.8%
CfSH5 + PV and Solar + Allowable Solution to Reach Zero Carbon	39.8%	12.2%	-2.5%

3.43 The findings on the projected viability of Case Study 2, in **2013** and **2016**, are summarised below:

- In 2013, Case Study 2 is viable with either a city wide CHP connection or PV and Solar Thermal technology, at returns of 27.5% and 23.5% respectively, in a “Hot” market.
- The scheme can provide Code 5 standards and a city wide CHP connection, at a return of 20.5%
- PV and Solar Thermal technology would exceed the emissions target by circa 20,200 kg/ CO2 per annum, but would render the scheme unviable, with a return of 16.7%.
- All other scenarios in 2013 are unviable for Case Study 2.
- In 2016, Case Study 2 can accommodate either a city wide CHP connection or PV and Solar Thermal technology, with Code 5 standards in a “Hot” market; providing returns of 26.3% and 22.7% respectively.
- Case Study 2 can meet the required carbon emissions shortfall for a city wide CHP connection (-7,900 kg/ CO2) through Allowable Solutions and still be viable at 25.4%.
- Although PV technology meets the carbon emissions target of Zero Carbon, with an excess of 3,000 kg/CO2, Solar Thermal has a shortfall of -14,500 kg/ CO2. The collective amount of emissions from combining both technologies is -11,500 kg/CO2. This weighty shortfall can be met via Allowable Solutions and still be viable in a “Hot” market, at a return of 21.4%.
- A “Moderate” market in 2016 would enable Case Study 2 to be viable with city wide CHP connections with construction costs aligning with Code 3 and Code 4 regulations. However, the compliance target of 2016 is that of Code 5.
- All other scenarios in 2016 are unviable for Case Study 2.

Case Study 3

3.44 Table 3-10 below shows the effects on the viability for Case Study 3 in different market conditions with additional renewable technologies and construction costs related to the varying Codes for Sustainable Housing.

Table 3-10: Case Study 3: 2011 Viability Outcomes

Case Study 3	Hot	Moderate	Cold
CfSH3	29.4%	16.5%	3.4%
Cfsh3 + connected CHP	25.4%	12.4%	-0.7%
CfSH4	28.6%	15.7%	2.7%
CfSH4 + connected CHP	24.6%	11.7%	-1.4%
CfSH4 + scheme CHP	23.9%	11.0%	-2.0%
CfSH4 + PV and Solar	12.7%	-0.2%	-13.2%
CfSH5	18.9%	7.0%	-5.1%
CfSH5 + connected CHP	15.2%	3.3%	-8.8%
CfSH5 + scheme CHP	14.5%	2.7%	-9.4%
CfSH5 + PV and Solar	4.2%	-7.7%	-19.8%

3.45 The simulation reveals that in a "Hot" market Case Study 3 is viable when providing a city wide CHP connection and a CHP scheme development whilst meeting Code 4 non-energy construction regulations. The scheme becomes unviable once it incorporates PV and Solar Thermal technology. Beyond and including this scenario, all other scenarios for Case Study 3 are unviable, as the case study comprises of apartments only, which are inherently less lucrative.

3.46 The findings on the projected viability of Case Study 3, in **2013** and **2016**, are summarised below:

- In 2013, Case Study 3 can deliver a city wide CHP connection or a CHP scheme at Code 4 and construction that meets Code 5 but still fails to accommodate PV and Solar Thermal technology with Code 4 regulations or beyond.
- All other scenarios in 2013 are unviable for Case Study 3.
- In 2016, Case Study 3 can accommodate Code 5 standards using a city wide CHP connection, providing a return of 22.9%, a CHP scheme, providing a return of 22.3%.
- The scheme can also meet the -28,800 kg/CO2 emissions shortfall from the 2016 Zero Carbon Target and still provide a return of 22.9%.
- The scheme is viable in a "Moderate" market, meeting Code 3 and Code 4 requirements. However these requirements will be redundant by 2016.
- All other scenarios in 2016 are unviable for Case Study 3.

Case Study 4

3.47 Table 3-11 below shows the effects that additional LZC technologies and CfSH construction requirements will have on the viability of Case Study 4 in different market areas.

Table 3-11: Case Study 4: 2011 Viability Outcomes

Case Study 4	Hot	Moderate	Cold
CfSH3	38.6%	25.3%	11.1%
Cfsh3 + connected CHP	33.9%	20.6%	6.4%
CfSH4	37.2%	24.1%	10.1%
Cfsh4 + connected CHP	32.6%	19.4%	5.4%
CFSH4 + scheme CHP	31.6%	18.5%	4.5%
CFSH4 + PV and Solar	28.1%	15.0%	0.9%
CfSH5	29.4%	17.0%	3.8%
CfSh5 + connected CHP	25.0%	12.6%	-0.6%
CFSH5 + connected CHP + Allowable Solution to Reach Zero Carbon	24.5%	12.1%	-1.1%
CFSH5 + scheme CHP	24.1%	11.8%	-1.5%
CFSH5 + scheme CHP + Allowable Solution to Reach Zero Carbon	23.6%	11.2%	-2.1%
CFSH5 + PV and Solar	20.8%	8.5%	-4.8%
CFSH5 + PV and Solar + Allowable Solution to Reach Zero Carbon	20.1%	7.7%	-5.6%

3.48 Case Study 4 is viable in the majority of scenarios in a "Hot" market, including the provision of PV and Solar Thermal technology in line with Code 5 regulations, which is the most expensive scenario being tested. The case study, in a "Hot" market, would even be viable if it were to incorporate Allowable Solutions into the scheme, to meet the combined shortfall of PV and Solar Thermal technology (-38,300 kg/CO2) while providing non-energy construction requirements in line with Code 5 regulations.

3.49 Case Study 4 can be deliverable in a "Moderate" market to provide a city wide CHP connection with Code 3 construction requirements, and Code 4 non-energy construction requirements. A city wide CHP connection coupled with Code 4 non-energy requirements would provide a return of 19.4%; 0.6% off the viability threshold. All other scenarios are unviable in Case Study 4.

3.50 The results regarding the projected viability of Case Study 4, in **2013** and **2016**, are listed below:

- In 2013, Case Study 4 is viable in all scenarios in a "Hot" market. These scenarios include the most expensive scenario, which is meeting the emission shortfall to Zero Carbon with PV and Solar and Allowable Solutions, with a return of 24.0%.
- In a "Moderate" market projected to 2013, Case Study 4 can either include a city wide CHP connection or a CHP scheme, meet code4 using, with a return of 23.1% and 22.2%, respectively, however, factoring in PV and Solar Thermal technology renders it unviable.
- In 2016, all scenarios are viable in a "Hot" market, with the most expensive scenario (CfSH 5 + PV and Solar Thermal technology + Allowable Solution to reach Zero Carbon) providing a return of 30.0%.
- Case Study 4 is able to meet code 5 using a city wide CHP at a return of 21.3%. To meet the -26,500 kg/ CO2 shortfall to Zero Carbon with CHP and Allowable Solutions would provide a return of 20.8%
- Case Study 4 is able to meet code 5 using a CHP scheme at a return of 20.5%. To meet the -26,500 kg/ CO2 shortfall to Zero Carbon with CHP and Allowable Solutions would provide a return of 20.0%
- All other scenarios in 2016 are unviable for Case Study 4.

Case Study 5

3.51 Table 3-12 below shows the effects on the viability of Case Study 5 when additional LZC technologies and CfSH construction requirements have been included, in different market areas.

Table 3-12: Case Study 5: 2011 Viability Outcomes

Case Study 5	Hot	Moderate	Cold
CfSH3	34.4%	21.2%	7.5%
CfSH3 + connected CHP	30.0%	16.8%	3.1%
CfSH + scheme CHP	29.2%	16.0%	2.3%
CfSH4	33.1%	20.1%	6.5%
CfSh4 + connected CHP	28.8%	15.7%	2.2%
CfSH4 + scheme CHP	28.0%	14.9%	1.4%
CfSH4 + PV and Solar	20.5%	7.4%	-6.1%
CfSH5	24.1%	11.9%	-0.7%
CfSH5 + connected CHP	20.1%	7.9%	-4.8%
CfSH5 + connected CHP + Allowable Solution to Reach Zero Carbon	18.9%	6.7%	-6.0%
CfSH5 + scheme CHP	19.3%	7.2%	-5.5%
CfSH5 + scheme CHP + Allowable Solution to Reach Zero Carbon	18.0%	5.8%	-6.8%
CfSH5 + PV and Solar	12.3%	0.2%	-12.5%
CfSH5 + PV and Solar + Allowable Solution to Reach Zero Carbon	11.8%	-0.4%	-13.1%

3.52 The returns for Case Study 5 can provide additional renewable technologies, up to and including a city wide CHP connection at Code 5 non-energy construction levels. A CHP scheme with Code construction levels is 0.7% off of the viability threshold, implying that a small alteration in revenue would enable the inclusion of this technology.

3.53 Currently, the scheme can accommodate non-energy construction requirements that are in compliance with Code 3 and Code 4, in a "Moderate" market. All other scenarios are unviable in Case Study 6.

3.54 The effects on the projected viability of Case Study 5, in **2013** and **2016**, are summarised below:

- The returns for Case Study 5 in the tested scenarios of a "Hot" market areas in 2013 has significant positive change. The projected sales and costs of the scheme can accommodate the majority of the renewable technologies and the construction costs associated to the different Code levels.
- Meeting the Code 4 standards provides a return of 36.6%. By using a city wide CHP connection, a CHP scheme or PV and Solar Thermal technology would provide returns of 32.4%, 31.7% and 24.4%, respectively.
- All scenarios are viable, with the exceptions of CfSH 5 and PV and Solar Thermal technology and CfSH 5 and PV and Solar Thermal technology with Allowable Solutions to reach Zero Carbon.
- In "Moderate" market, Case Study 5 has a return of 23.3% with Code 4 standards which are required by 2013, however, factoring in a city wide CHP connection or PV and Solar Thermal technology would render the scheme unviable.

- In 2016, all scenarios are considerably viable in a "Hot" market, with the most expensive scenario (CfSH 5 + PV and Solar Thermal technology + Allowable Solution to reach Zero Carbon) providing a return of 20.9%; the emissions deficit to be met through allowable solutions is -50,200 kg/ CO2.
- Case Study 5 is able to meet code 4 using a city wide CHP connection or a CHP scheme in a "Moderate" market, at a return of 24.2% and 23.5%, respectively. However, this requirement will be superseded by Code 5 regulations by 2016.
- All other scenarios in 2016 are unviable for Case Study 5.

Case Study 6

3.55 Table 3-13 below shows the developer returns that can be expected from the Case Study 6 scheme in different market areas, when additional renewable technologies and CfSH construction requirements have been included.

Table 3-13: Case Study 6: 2011 Viability Outcomes

	Case Study 6		
	Hot	Moderate	Cold
CfSH3	37.4%	23.9%	10.0%
Cfsh3 + connected CHP	33.0%	19.5%	5.5%
CFSH + scheme CHP	32.1%	18.7%	4.7%
CfSH4	36.1%	22.8%	8.9%
Cfsh4 + connected CHP	31.7%	18.3%	4.5%
CFSH4 + scheme CHP	30.9%	17.5%	3.7%
CFSH4 + PV and Solar	22.9%	9.6%	-4.3%
CfSH5	26.5%	14.1%	1.2%
CfSh5 + connected CHP	22.4%	10.0%	-2.9%
CFSH5 + connected CHP + Allowable Solution to Reach Zero Carbon	21.2%	8.8%	-4.1%
CFSH5 + scheme CHP	21.7%	9.3%	-3.6%
CFSH5 + scheme CHP + Allowable Solution to Reach Zero Carbon	20.3%	7.9%	-5.0%
CFSH5 + PV and Solar	14.2%	1.9%	-11.1%
CFSH5 + PV and Solar + Allowable Solution to Reach Zero Carbon	13.7%	1.4%	-11.6%

3.56 In a "Hot" market, Case Study 6 provides high returns of the code can accommodate the majority of LZC technologies and non-energy construction regulations of the code. In existing "Hot" market areas, such a scheme can meet Code 5 levels. Beyond that, it can include either both city wide CHP connections or CHP schemes, as well as fund Allowable Solutions to get to Zero Carbon benchmarks. Case Study 6 becomes unviable with the inclusion of PV and Solar Thermal technology to meet the Code.

3.57 Case Study 6 can meet Code 4 in a "Moderate" market. All other scenarios are unviable in Case Study 6.

3.58 The effects of tested scenarios on the projected viability of Case Study 6, in **2013** and **2016**, are summarised below:

- Similar to the current outlook, Case Study 6 enables code 5 to be met using most renewable technology add-ons in a “Hot” market, except for the inclusion of PV and Solar Thermal technology.
- Case Study 6 can meet code 4 using a city wide CHP connection, a CHP scheme or PV and Solar Thermal technology, with returns of 35.3%, 34.5% and 26.8% respectively.
- Case Study 6 can meet code 5 using a city wide CHP connection, with a return of 25.7%, and can incorporate the cost of Allowable Solutions (to meet a Zero Carbon deficiency of -277,500 kg/ CO2) with a return of 24.5%.
- Case Study 6 can also meet code 5 using a CHP scheme, with a return of 25.0%. The scheme is still viable with the inclusion of Allowable Solutions, to counterforce a deficit of -310,800 kg/ CO2, with a return of 23.7%.
- In a “Moderate” market, the scheme can meet code 4 using a city wide CHP connection or a CHP scheme at Code 4 building construction regulations, with returns of 21.6% and 20.9% respectively.
- All other Case Study 6 scenarios are unviable in 2013.
- In 2016, all scenarios are viable in a “Hot” market, with the most expensive scenario (CfSH 6 + PV and Solar Thermal technology + Allowable Solution to reach Zero Carbon) providing a return of 22.8%.
- Case Study 6 is able to meet code 5 using a city wide CHP connection, a CHP scheme or PV and Solar Thermal technology with Code 5 non-energy building regulations in a “Hot” market area, at a return of 30.7%, 30.1% and 23.2%, respectively. The returns including allowable solutions to each of these three options are 29.6%, 28.8% and 22.8%, respectively.
- The scheme can meet Code 4 (which become redundant in 2016) and Code 5 in a “Moderate” market, but beyond this, the case study becomes unviable.

4. Recommendations

Summary of Findings

4.1 **Affordable Housing impact:** The affordable housing component has quite a detrimental influence on 'Hot' market areas simply because the influence of higher affordable housing requirements. 'Moderate' and 'Cold' markets have a 20% affordable housing requirement, but these reflect less favourable economic climates, and are therefore also intrinsically low.

4.2 **Housing Types:** In assessing the specific housing types between Apartments (CS1 and CS3) and Housing (CS2 and CS4), it was found that developing Houses generally were more viable due to higher sale prices and lower construction costs. This was increasingly favourable for larger projects. In mixed residential schemes (CS5 and CS6), the balance of apartments and houses was maintained to determine size impact of individual projects.

CfSH Code 3 in 2011:

- 'Hot' Markets: All case studies are able to satisfy the requirements of Code 3, however, the additional costs of city wide CHP connection for CS1 renders the scheme unviable.
- 'Moderate' Markets: Case study 5 and Case Study 6 (i.e. above 50 units) were able cater to the additional costs of Code 3. Case Study 4, which had only housing units, was found to be viable with city wide CHP technology.
- 'Cold' Markets: All case studies were found to be unviable.

CfSH Code 4 in 2011, 2013 *(Based on projected sales CAGR 3% and costs CAGR 2%)***:**

- 'Hot' Markets: All case studies are able to absorb the requirements of Code 4. However, the additional costs of city wide CHP connection for Case Study 1 made the scheme unviable. In the 2013 projected rates, all case studies were found to be viable including the adoption of Code 4 with a city wide CHP connection.
- 'Moderate' Markets: Case study 4, Case Study 5 and Case Study 6 (i.e. above 50 units) could achieve the minimum requirements of Code 4. In the 2013 projected rates, Case Study 4 was found to be viable with a city wide CHP connection; Case Study 4, Case Study 5 and Case Study 6 were able to achieve Code 4 compliance but only Case Study 4 and Case Study 6 could meet the a city wide CHP connection in addition. Case Study 6 was able to achieve a Scheme CHP adoption. However utilisation of PV and Solar Thermal technology to meet the code remained unviable in all cases.
- 'Cold' Markets: All case studies with projections continued to be unviable.

CfSH Code 5 in 2011, 2013 and 2016 *(Based on projected sales CAGR 3% and costs CAGR 2%)***:**

- 'Hot' Markets: Compliance with Code 5 was only achievable for both housing and mixed residential case studies i.e. Case Study 2, Case Study 4, Case Study 5 and Case Study 6. However only Case Study 4, Case Study 5 and Case Study 6 were able to achieve zero carbon using a city wide CHP connection and Allowable Solutions. Case Study 6 was able to achieve zero carbon using a Scheme CHP facility and Allowable Solutions. Case Study 4 was able to achieve minimum compliance to Code 5 using PV and Solar thermal technologies as well. Using the 2013 projected rates, all case studies except for Case Study 1 were found to achieve Code 5 minimum requirements. In the 2016 projections, Case Study 2, Case Study 4, Case Study 5 and Case Study 6 were able to achieve maximum compliance (Code 5 Zero Carbon target) through the adoption of PV and Solar Thermal and Allowable Solutions. Case Study 1 was able to achieve only Code 5 minimum compliance while Case Study 3 was unable to achieve Code 5.
- 'Moderate' Markets: All case studies were unable to achieve Code 5 compliance. In the 2013 projected rates, Case Study 4 does achieve Code 5 minimum compliance. In the 2016

projections, Case Study 4 was found to achieve zero carbon using a city wide CHP connection and Allowable Solutions, while Case Study 6 can achieve the minimum Code 5 requirements. All other case studies remained unviable.

- ‘Cold’ Markets: All case studies with projections continued to be unviable.

4.3 The studies reveal that it is currently possible to meet the energy reduction requirements for Code 3 through both the Part L Building Regulations and through deployment of renewable energy technologies, in a “Hot” market area. This is also true most case studies in reaching Code 4 levels. In a “Moderate” market, it is the case studies that comprise of larger sized schemes that can currently provide renewable technologies to meet Code 4, while also having capacity to incorporate affordable housing contributions; these are Case Study 4, Case Study 5 and Case Study 6.

4.4 The affordable housing component has a significant impact on the viability of projects meaning there is a need to balance affordable housing and compliance with other policies, especially for project between (15-50 units) and for schemes which include a higher proportion of apartment units especially.

4.5 Case Study 1 and Case Study 2 are at the threshold amount of units that requires an affordable housing component. As such, they are both marginally viable in the favourable conditions of constructing the scheme to CfSH 3, in a “Hot” market. If affordable is neglected, or negotiated down, the schemes are able to reach the carbon reduction targets more easily in both “Hot” and “Moderate” markets, as is shown in Section 3. As the costs and sales of the cases studies are projected to 2013 and 2016, it is evident that all case studies become more viable and have more capacity to include LZC technologies and reduce carbon emissions, without compromising the viability threshold.

Policy Recommendations

National Policy Context

4.6 Section 1 of this Technical Note provides a brief overview of the national planning policies relating to renewable energy. It is important to demonstrate how the Council’s policy approach relates to guidance within the existing national planning policy guidance. PPS 1 Supplement identifies that planning authorities should provide a framework that promotes and encourages LZC energy generation and that policies should be designed to promote and not restrict LZC energy and supporting infrastructure.

4.7 Planning authorities are expected to have evidence based understanding of the local feasibility and potential for LZC technologies in their area. This study has considered this and has revealed the financial potential of different development scheme typologies to contribute towards meeting the objectives of national planning policy guidance.

4.8 It is appropriate for planning authorities to:

- Set out a target percentage of the carbon emissions to be reduced in new development, by the use of decentralised and LZC energy sources where it is viable. The target should avoid prescription on technologies and be flexible in how carbon savings from local energy supplies are to be sourced;
- Bring forward development areas or site-specific targets, where there are particular and demonstrable opportunities for greater use of decentralised and renewable or LZC energy than the target percentage, in order to secure this potential;
- Set out the type and size of development to which targets will be applied; and
- Ensure there is a clear rationale for the target and it is properly tested.

4.9 Where there are existing decentralised energy supply systems, or firm proposal, planning authorities can expect proposed development to connect to an identified system, or be designed to be able to connect in future. When specifying requirements for new development to secure energy from decentralised and LZC energy sources, it is appropriate for the Council to set specific requirements to facilitate connection.

4.10 Policies are required to demonstrate that what is proposed is evidence-based and viable, having regard to the overall costs of bringing sites to the market (including the costs of any necessary supporting infrastructure) and the need to avoid any adverse impact on the development needs of communities. This note has reviewed the councils Core Strategy policies and provided further evidence, examining the issues of viability and feasibility in Birmingham. This technical note has considered these elements when appraising the six different case studies and the varying alterations of the market circumstances in the city.

Birmingham City Core Strategy Policy

4.11 Policy SP5 sets out a carbon reduction target for the city which is to reduce its Carbon Footprint by 60% by 2026. SP5 states that this aim will be met by ensuring new neighbourhoods and buildings are energy efficient, promoting the recycling and re-use of waste and encouraging lower dependency on carbon fuels. The largest contribution towards meeting the target will be made from retro-fitting the existing building stock in order to improve energy efficiency.

4.12 Furthermore, application of the policy should reflect the limitations in certain locations or markets in the city that may not accommodate the requirements of Policy SP7, which holds that all new residential development should meet Code 3 requirements currently, Code 4 requirements by 2013 and Code 6 requirements by 2016. The Places of the Future SPD provides guidance on implementation of the policy as the definitions of the Codes for Sustainable Homes have altered recently, Policy SP7 should be amended to reflect these new designations; primarily that Code 6 has been replaced by a Code 5 with Zero Carbon specification.

4.13 The benchmark of 50 residential units, as set in Policy SP8, for the inclusion of a CHP connection has been tested through the feasibility and viability assessment conducted by Atkins, in order to determine whether this scale of development is sufficient to add to it this specific renewable technology. The study found that development schemes comprising of 50 units (and even schemes comprising of only 15 houses) were initially viable and able to accommodate a city-wide CHP connection to meet with the current Code 3 requirements. However, the results revealed that these provisions are only viable in “Hot” markets or locations that can demand higher sales values. In “Moderate” or “Cold” markets, the inclusion of CHP facilities for schemes of 50 units rendered the projects unviable. In addition to this, it was found that schemes comprising of 200 units and above were viable with scheme-wide CHP facilities in both “Hot” and “Moderate” markets.

4.14 In terms of technical feasibility, standalone provision of CHP plants connected to residential development should normally have a minimum of 200 homes in the scheme for them to be a technically feasible solution. This is because CHP is sized on the hot water demand of the properties, which provides the suitable base load for energy requirements. On site CHP may normally be appropriate for mixed use schemes whereby sufficient base load (provided by commercial, industrial, community uses) and hot water/heat demand for a CHP system to operate efficiently. If there is insufficient base load especially during the day, then any unused heat will be wasted / not utilised. The Heat Mapping and Decentralised Energy Feasibility Study, further highlighted the potential to deliver significant costs savings and reduced carbon emissions through the West Midlands conurbation and ensuring area wide CHP networks anchored by high demand users can serve wider areas plants serve wider areas. This solution can be cost effective by plants having economies of scale. As such, it is recommended that Policy SP8 is modified to increase the threshold of residential units requiring a standalone CHP plan to 200 units. Schemes of all sizes should normally be required to connect with planned networks. The energy hierarchy approach set out below can be used to structure this in the policy.

Employment Land & Premises

4.15 The focus of this technical note was to assess the effect on the viability of a range residential development schemes. Schemes that incorporate commercial development, or indeed employment land, are likely to more viable than residential developments due to the lack of costs that are associated with affordable housing provisions, Part L Building Regulations or certain planning obligations. Although non-residential development should adhere to the BREEAM very good standards and should contribute towards specific planning obligations, the revenues of such development are usually less affected than their residential counterparts.

4.16 It is advised that non-residential development proposals are subject to a Carbon Statement approach, set out in the Places of the Future SPD, to inform the Council on the levels of energy that are required by such developments and to identify the commercial developments can provide LZC technology in order to meet carbon reduction targets. It should be noted also that energy consumption patterns are more concentrated and intense than those of residential units. These can be identified by mapping heat mapping clusters, which can inform the Council of priority opportunities where decentralised LZC plants would ideally be located.

Allowable Solutions

4.17 Allowable solution serves as the requirement to account for the carbon emissions that are not expected to be achieved onsite through carbon compliance . These solutions can cover regulated emissions (space heating, ventilation, hot water and fixed lighting) covered by Part L of the Building Regulations and unregulated emissions including emissions from cooking and appliances. Allowable Solutions would include commuted sums collected in a fund that would be directed towards local energy efficiency programmes, such as Birmingham Energy Savers, to retrofit of the existing building stock, invest in renewable technology or fund the enhancement of the city's CHP infrastructure, to implement the Core Strategy. This could be run by an energy service company (ESCO) or a climate investment fund. Further studies would be required to determine the degree of capacity enhancement and investment required for the CHP network to meet housing and non-residential demand.

4.18 Depending on the location and achievable affordable housing, the rate for "allowable solution" should be raised for larger projects (i.e. over 50 units) to encourage them to use new technology rather than financially contribute to allowable solution component. Currently the range of £50 to £100 carbon / tonne over 30 years appears to have too low an impact on developer margins. The allowable solutions may be revised to consider varying impact based on size of the project in order to encourage larger projects to develop onsite provisions.

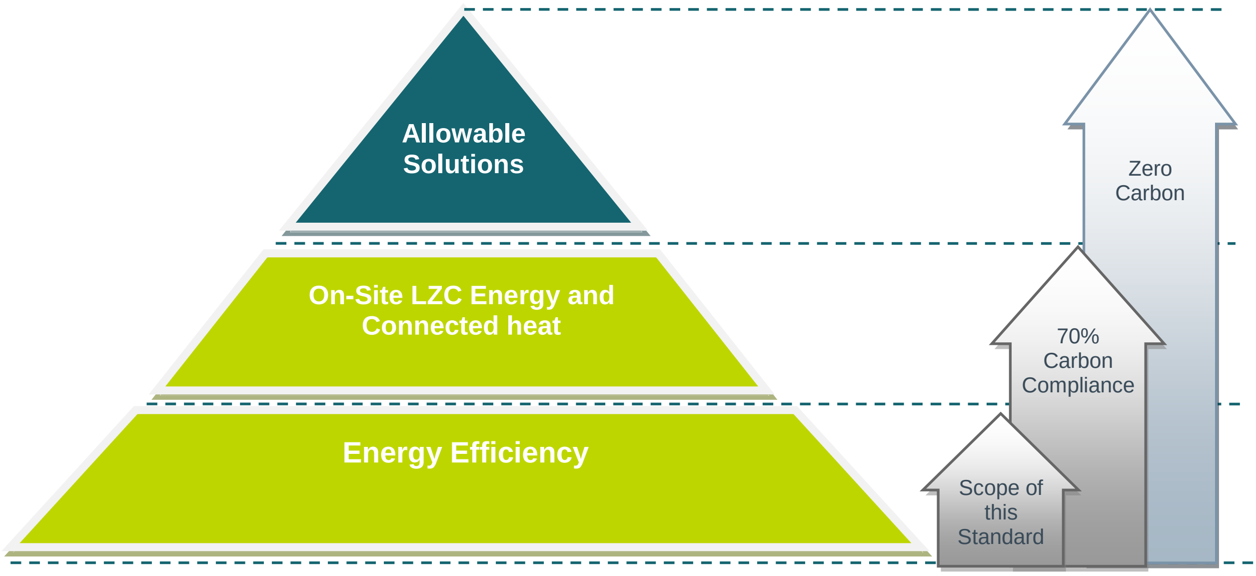
LZC Hierarchy

4.19 Where the viability of a scheme can be proven to have sufficient returns (above the 20% developer return), there is an opportunity to achieve greater CO2 reductions. An energy hierarchy approach is outlined which sets out the sequence of potential technology choices to reflect opportunities within the city. The Places for the Future SPD provides further explanation on assessment criteria and the Carbon Budget approach. It is suggested that a hierarchy for LZC technologies should list as follows::

- Non-energy fabric provision, in line with the Part L Building Regulations of the relevant CfSH
- Combined Heat & Power connections and options for onsite CHP;
- Other means of low and zero carbon technology to reduce emissions and may be more affordable than PV and Solar Thermal technology. These may include the types of LZC technology, where it is feasible such as:
    - PV and Solar Thermal technology;
    - Biomass Heating;
    - Biomass Combined Heat & Power;
    - Ground Source heat pumps;
    - Air Source heat pumps; or
    - Wind Turbines;
    - Small scale Hydro Power; and
    - Allowable Solutions

4.20 This hierarchy is portrayed in the figure below:

Figure 4-1: LZC Hierarchy

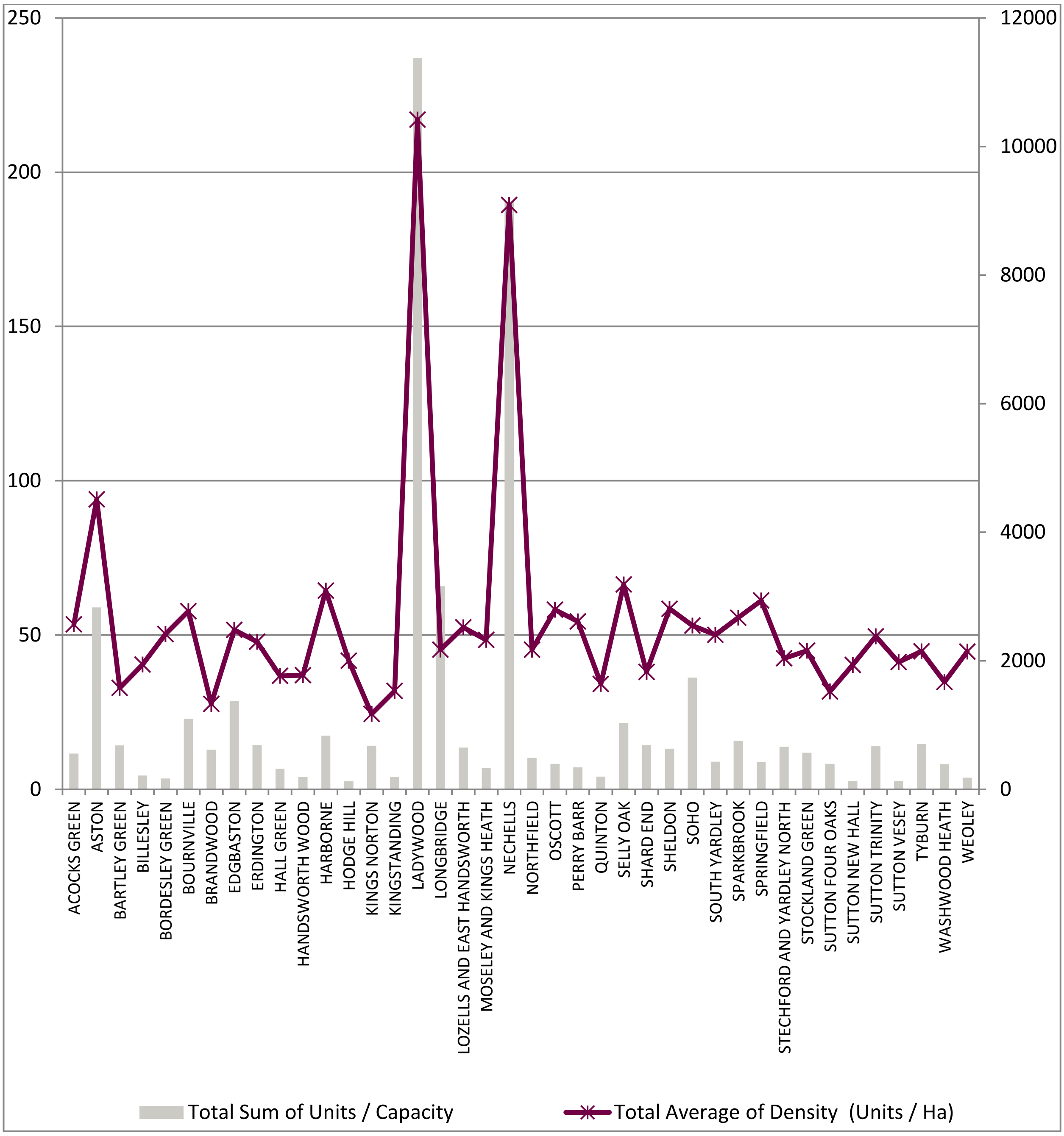


Appendices

Appendix A. Birmingham SHLAA Analysis

A.1.1. The Birmingham SHLAA analysis displayed in Figure A-1 a distribution of housing densities between 35 to 100 units / Ha. Of specific note is the concentration of housing supply and density in Ladywood and Nechells. The summary of analysis has been tabulated in has been tabulate in Table 2-2, 2-3 and 2-4 located in Market assessment section of this report.

Figure A-2: SHLAA supply across wards for housing Density and estimated Units



Appendix B. Code for Sustainable Homes Compliance Standards

B.1.1. For the CfSH compliance standards described in Table B-1 the basic assumptions for demand assessment and target compliance achieved for CfSH Level 3, Level 4 and Level 5 are shown below. This included Dwelling Regulated energy considers the demand (electricity and heat) for a house and apartment and subsequent target reduction in demand with CfSH Level 3, Level 4, and Level 5.

B.1.2. The CO2 emissions (kgCO2) displays the benchmark standards adopted in 2006 and the subsequent 25% in emissions in 2010, 44% reduction in 2013 and the subsequent achievement of zero-carbon in achievement in 2016. This includes the improvements through Fabric energy consideration and does not take into account the impact from renewal energy adoption. As an exercise, the impact of unregulated energy requirements (as required by the original CfSH Level 6) has been included.

Table B-1: Dwellings Emission and Energy Assumptions

Dwelling Emission and Energy Summary Table

Dwelling Regulated Energy Use / kWh - Demand

Standard	House Electricity	House Heat	House Total	Apartment Electricity	Apartment Gas	Apartment Total
2006 dwelling	1067.9	10614.1	11682	1037	7225	8262
Code level 3/ Part L 2010 (base year)	-	-	-	-	-	--
Code Level 4 (Fabric Energy Efficiency Standard*) 2013	719.8	6855.8	7575.6	756.5	4751.5	5508
Code Level 5 - Zero Carbon 2016	719.8	6855.8	7575.6	756.5	4751.5	5508
Code Level 6**	N/A	N/A	N/A	N/A	N/A	N/A

* Potential Building Regulations 2013

** No energy demands have been modelled for a CSH 6 Home as un-regulated energy (applicable for CfSH 6) are to be excluded from Building Regulations and outside the Governments definition of Zero Carbon Homes

Dwelling Regulated Energy CO2 Emissions / kgCO2

Standard	House Electricity	House Heat	House Total	Apartment Electricity	Apartment Gas	Apartment Total
2006 dwelling	577.7	1948.7	2526.5	561.0	1326.5	1887.5
Code level 3/ Part L 2010 (base year)***			1894.9			1415.6
Code Level 4 (Fabric Energy Efficiency Standard*) 2013***	389.4	1258.7	1648.1	409.3	872.4	1281.6
Code Level 5 - Zero Carbon 2016****			1298.0			1190.0
Code Level 6**	N/A	N/A	N/A	N/A	N/A	N/A

*** 2010 Emissions are based on a 25% reduction over 2006, as per typical practice. The step change from 2006 to 2010 to 2013, does not replicate the previous thinking of a 25% then 44% reduction for 2013, where only a marginal improvement is obtained in 2013. Importantly, the 2013 &2016 Energy demands are based on a revised methodology of working to Built Performance in preference to Design Performance. It is perceived that working to this method will provide more actual carbon savings as current practice (2010 & 2006 regs) often resulted in higher actual emissions than the design model. The Zero Carbon hub expects that this F.E.E.S building standard will result in a saving of circa 25-30% over 2006.

**** The 2016, Zero Carbon, emissions are based on the predicted emissions allowed for the dwelling type, using the Zero Carbon Hub's proposed Carbon Compliance limit for a Low Rise Apartment and an Attached House. This limit will need to be achieved through, fabric energy efficiency and/or on-site low or zero carbon energy systems or connected heat. The emission figure itself will then need to be achieved through Allowable Solutions and/or further fabric improvement or on-site LZC contribution.

CO2 Emissions Factor (Source: 2011 Guidelines to DEFRA/DECC's GHG Conversion factors for Company Reporting)

Electricity	0.541
Gas	0.1836

CO2 Emissions - Carbon Compliance Limit / kgCO2/m2/year

Detached Homes	10	This figure is the limit of CO2 emissions that are allowed for the dwelling type, without using Allowable Solutions. This limit has to be achieved via the fabric energy efficiency standard and on-site LZC/connected heat
Attached Houses	11	
Low Rise Apartments	14	

CO2 Emissions - Carbon Compliance Target / kgCO2/year

Attached Houses	**350.1**	These are the emission reductions that will need to be achieved on-site through LZC systems to achieve 'Zero Carbon' - effectively the difference between the emissions expected from a F.E.E.S dwelling and the Carbon Compliance Limit
Low Rise Apartments	**91.6**	

Dwelling Regulated and Un- Regulated Energy CO2 Emissions / kgCO2			
Standard	**House Total**	**Apartment Total**	***** The CSH 6 Emissions are a sum of the estimated un-regulated emissions for the dwelling type and the emissions from a Code Level 4 (Fabric Energy Efficiency Standard*) 2013 dwelling.
Un-Regulated Emissions	**1770**	**1275**	
2006 dwelling	0.0	0.0	
Code level 3/ Part L 2010 (base year)***	0.0	0.0	
Code Level 4 (Fabric Energy Efficiency Standard*) 2013***	0.0	0.0	
Code Level 5 - Zero Carbon 2016****	0.0	0.0	
Code Level 6***	**3418.1**	**2556.6**	

Appendix C. Renewal Technology Costing Assumptions

C.1. Combined Heat and Power Assumptions:

C.1.1. Combined heat and power (CHP) have been evaluated for city-wide and Scheme-wide / on-site provisions based on the scale of the project. Table C-2 introduces the assumptions for the calculating the costs for adoption of CHP and its reduction in carbon (kgCO2) targets:

- The variation in costs for City-wide scheme, Scheme-wide and On-site CHP adoption.
- The cost per unit (in green), cost per square meter (in Orange) and the reduction carbon impact per square meter in kgCO2/m2 (in blue) for each type of CHP approach mentioned above.
- The costs for city-wide CHP and scheme-wide schemes was appraised for all case studies, however this should be differ from location and physical constraints of each site.

Table C-2: CHP Technology Connection costs

	City-wide £/install	£/m2	kgCO2 red. m2	Scheme-wide £/install	£/m2	kgCO2 red. m2	On-site £/install	£/m2	kgCO2 red. m2
House	6,858	58	6.5	8,217	70	6.0	5,019	42.53	6.0
Apt.	4,550	54	6.8	5,300	62	6.0	3,800	44.71	6.0

C.1.2. The costs for each type of CHP technology has been broken by type of development i.e. House and Apartment as seen in Table C-3. Furthermore, the assumptions of costs District Heating (DH) infrastructure costs have been introduced in Table C-4, which determined the infrastructure costs per unit for City-wide CHP adoption. Table C-5 is a summary of energy consumption and carbon reduction assumptions adopted for the purpose of the carbon target calculations.

Table C-3: Generic CHP Costs for each type of development

	Total generic Connection cost £		
	Low rise flat*	Terrace*	Semi-det (dense)
On site CHP + District Heating **Connection to city CHP+DH** **Scheme wide CHP+DH**	4,400	7,500	8,300

Indicative costs from
http://www.idea.gov.uk/idk/core/page.do?pageId=23210852

Table C-4: Generic CHP Costs for type of development

District Heating infrastructure costs break-down £				
	District Heating infrastructure cost	District Heating branch cost	Hydraulic Interface Unit +heat meter	**Total**
House	2,719	3,198	2,300	8,217
Apt.	1,500	1,500	2,300	5,300

Indicative costs from
http://ecolateral.org/Economics/bankofsustainibilty/distributedheatpoyyre0409.pdf

Table C-5: Carbon reduction by each CHP technology

Gas engine CHP specifications	City - wide	Scheme-wide	On-site
Elec efficiency %	38	28	28
Thermal efficiency	42	52	52
Cap. Cost £/kWe	657	864	864

C.1.3. In order to determine emissions from electricity and heat for the CHP the following calculations was adopted:

CO2 factors	
Natural gas	0.1836
Grid elec.	0.541

$$\text{Emissions (in kgCO}_2\text{e) per kWh electricity} = \frac{2 \times \text{total emissions (in kgCO}_2\text{e)}}{2 \times \text{total electricity produced} + \text{total heat produced (in kWh)}}$$

$$\text{Emissions (in kgCO}_2\text{e) per kWh heat} = \frac{\text{total emissions (in kgCO}_2\text{e)}}{2 \times \text{total electricity produced} + \text{total heat produced (in kWh)}}$$

DEFRA equations for calculating gas and electricity factors for CHP assuming 2:1 heat to electricity ratio

C.1.4. **City-wide and Site-wide Calculations for CHP:** The two tables below describe the carbon reduction impact calculated for City-wide CHP and Site-wide CHP based on the methodology described above.

Table C-6: City wide CHP assumptions

City wide CHP calculations

CHP heat efficiency	42%
CHP electrical efficiency	38%
Total CHP efficiency	80%
Distribution heat loss	10%

For 1000 kWh of gas input to CHP:

Total emissions	183.6	$kgCO_2e$
Total electricity produced	380	kWh
Total heat produced	420	kWh
Electricity emission factor	0.126829	$kgCO_2e$
Heat emission factor	0.11475	$kgCO_2e$

	House		Apt.	
Building area	118	m²	85	m²
Annual electricity kWh	719.8	kWh	756.5	kWh
Annual heat kWh	6855.8	kWh	4751.5	kWh
Annual electricity emissions	91	$kgCO_2e$	96	$kgCO_2e$
Annual heat emissions	787	$kgCO_2e$	606	$kgCO_2e$
Default design elect emissions	389	$kgCO_2e$	409	$kgCO_2e$
Default design heat emissions	1259	$kgCO_2e$	872	$kgCO_2e$
Annual electricity savings	298	$kgCO_2e$	313	$kgCO_2e$
Annual heat savings	472	$kgCO_2e$	266	$kgCO_2e$
Total annual emission reduction	770	$kgCO_2e$	579	$kgCO_2e$
Annual emission reduction per m²	6.53	$kgCO_2e$	6.81	$kgCO_2e$

http://www.delta-ee.com/downloads/Spark_Spreads_Delta_Research_Brief.pdf

Table C-7: Site wide CHP assumptions (Assuming no backup boilers or grid imports required)

Site wide CHP calculation - assuming no backup boilers or grid imports required

CHP heat efficiency	52%
CHP electrical efficiency	28%
Total CHP efficiency	80%
Distribution heat loss	10%

For 1000 kWh of gas input to CHP:

Total emissions	183.6	$kgCO_2e$
Total electricity produced	280	kWh
Total heat produced	520	kWh
Electricity emission factor	0.213107	$kgCO_2e$
Heat emission factor	0.11475	$kgCO_2e$

	House		Apt.	
Building area	118	m²	85	m²
Annual electricity kWh	719.8	kWh	756.5	kWh
Annual heat kWh	6855.8	kWh	4751.5	kWh
Annual electricity emissions	153	$kgCO_2e$	161	$kgCO_2e$
Annual heat emissions	787	$kgCO_2e$	606	$kgCO_2e$
Default design elect emissions	389	$kgCO_2e$	409	$kgCO_2e$
Default design heat emissions	1259	$kgCO_2e$	872	$kgCO_2e$
Annual electricity savings	236	$kgCO_2e$	248	$kgCO_2e$
Annual heat savings	472	$kgCO_2e$	266	$kgCO_2e$
Total annual emission reduction	708	$kgCO_2e$	514	$kgCO_2e$
Annual emission reduction per m²	6.00	$kgCO_2e$	6.05	$kgCO_2e$

C.1.5. **Comparison between 50 units and 200 unit threshold:** The two tables below described the carbon reduction calculate the annual impact of 50 unit project of apartments and 50 units housing project in comparison to a 200 unit project for apartments or housing. This was used to evaluate the critical threshold for efficiency for CHP.

Table C-8: CHP Comparison for 50 units and 200 unit scheme (House and Apartment)

	House			Apartment		
Number of houses	**50**			**50**		
Area of house	118	m²		85	m²	
Annual DHW demand	22.8	kWh per m² per house		22.8	kWh per m² per house	
Daily DHW demand	7.6	kWh per house		5.4	kWh per house	
Peak DHW demand	3.8	kW		2.7	kW	
Total peak demand	188.9	kW		136.1	kW	
CHP output	**Heat**		**Electricity**	**Heat**		**Electricity**
	190 kWth		95 kWe	136 kWth		68 kWe
CHP capital cost per house	£ 2,320			£ 2,211		
Annual CHP running hours	1500			1500		
Annual CHP heat	5,668	kWh		4,083	kWh	
Annual CHP electricity	2,850	kWh		2,040	kWh	
Annual CHP gas consumption	10,947	kWh		7,873	kWh	
Annual electricity exported to the grid	2,130	kWh		1,284	kWh	
Annual gas costs @ 5p/kWh	£ 547			£ 394		
Annual export electricity income @ 4p/kWh	£ 85			£ 51		
Cost for equivalent gas boiler based heat	£ 318			£ 229		
Cost for equivalent grid electricity @ 12p/kWh	£ 342			£ 245		
Annual savings	£ 198			£ 132		
Payback period [1]	11.7			16.8		
Annual CHP emissions per house	2,010	$kgCO_2e$		1,445	$kgCO_2e$	
Electricity emission factor	0.24	$kgCO_2e$		0.24	$kgCO_2e$	
Heat emission factor	0.12	$kgCO_2e$		0.12	$kgCO_2e$	
Emissions for exported electricity	503	$kgCO_2e$		303	$kgCO_2e$	
Emissions savings from displacing grid electricity	650	$kgCO_2e$		391	$kgCO_2e$	
Total net emissions from CHP	1,360	$kgCO_2e$		1,054	$kgCO_2e$	
Equivalent emissions for gas boiler	1,169	$kgCO_2e$		842	$kgCO_2e$	
Equivalent emissions for grid electricity	389	$kgCO_2e$		409	$kgCO_2e$	
Total annual emission reduction	199	$kgCO_2e$		197	$kgCO_2e$	
Annual emission reduction per m²	1.68	$kgCO_2e$		2.32	$kgCO_2e$	

	House			Apartment		
Number of houses	**200**			**200**		
Area of house	118	m²		85	m²	
Annual DHW demand	22.8	kWh per m² per house		22.8	kWh per m² per house	
Daily DHW demand	7.6	kWh per house		5.4	kWh per house	
Peak DHW demand	3.8	kW		2.7	kW	
Total peak demand	755.7	kW		544.4	kW	
CHP output	**Heat**		**Electricity**	**Heat**		**Electricity**
	760 kWth		380 kWe	550 kWth		275 kWe
CHP capital cost per house	£ 2,000			£ 1,500		
Annual CHP running hours	1500			1500		
Annual CHP heat	5,668	kWh		4,083	kWh	
Annual CHP electricity	2,850	kWh		2,063	kWh	
Annual CHP gas consumption	10,947	kWh		7,895	kWh	
Annual electricity exported to the grid	2,130	kWh		1,306	kWh	
Annual gas costs @ 5p/kWh	£ 547			£ 395		
Annual export electricity income @ 4p/kWh	£ 85			£ 52		
Cost for equivalent gas boiler based heat	£ 318			£ 229		
Cost for equivalent grid electricity @ 12p/kWh	£ 342			£ 248		
Annual savings	£ 198			£ 134		
Payback period	10.1			11.2		
Annual CHP emissions per house	2,010	$kgCO_2e$		1,450	$kgCO_2e$	
Electricity emission factor	0.24	$kgCO_2e$		0.24	$kgCO_2e$	
Heat emission factor	0.12	$kgCO_2e$		0.12	$kgCO_2e$	
Emissions for exported electricity	503	$kgCO_2e$		308	$kgCO_2e$	
Emissions savings from displacing grid electricity	650	$kgCO_2e$		398	$kgCO_2e$	
Total net emissions from CHP	1,360	$kgCO_2e$		1,051	$kgCO_2e$	

Equivalent emissions for gas boiler	1,169	$kgCO_2e$	842	$kgCO_2e$
Equivalent emissions for grid electricity	389	$kgCO_2e$	409	$kgCO_2e$
Total annual emission reduction	199	$kgCO_2e$	200	$kgCO_2e$
Annual emission reduction per m²	1.68	$kgCO_2e$	2.36	$kgCO_2e$

[1] This payback period is purely against the plant capital cost and does not include the cost of any additional plant, infrastructure or maintenance required

C.1.6. The annual emission reduction per m² does not change when the number of houses/apartments increases from 50 to 200. This is because the carbon savings are related to the number of hours the CHP plant is run, not the number of buildings attached to them. As the buildings attached are all domestic the heat demand is very low in the summer. Also the electricity and heating demand peaks are in the morning and evening. This does not provide the even heat and power demand required for cost effective CHP operation.

C.2. Solar Photovoltaic Assumptions:

C.2.1. Solar Photovoltaic Technology would depend on the available surface area, that angle and direction of the roof / surface and the efficiency energy production provided by the choice of PV panel. The assumptions for calculating the costs for Solar Photovoltaic (Solar PV) technology and its reduction in carbon (kgCO2) targets has been summarised in Table C-9 below. The Zero carbon hub task group considered that only 0.4 X ground floor area was considered as a suitable adjustment factor for estimating space available for PV.

Table C-9: Summary of Solar Photovoltaic Technology Assumptions

	Gross PV area m2	Net PV area m2	kWp	kWh/yr	kWh/m2/yr	m2 floorspace PV demand	kgCO2e red. Installation	kgCO2 red. m2	Cost £/install	Cost £/m2
House	23.6	22.82	3.29	2,771	23	118	1,499	12.7	9,870	83.64
x 4 standard apt top floor	136	135.29	19.505	16,723	49	340.0	9,047	26.6	58,515	172.10

CO2 factors	
Natural gas	0.1836
Grid elec.	0.541

Source: 2011 Guidelines to DEFRA/DECC's GHG Conversion factors for Company Reporting
http://archive.defra.gov.uk/environment/business/reporting/pdf/110819-guidelines-ghg-conversion-factors.pdf

Zero Carbon Hub Task Group Method		
PV area sizing factor	0.4	x ground floor area

http://www.zerocarbonhub.org/resourcefiles/CC_TG_Report_Feb_2011.pdf

C.2.2. The Zero Carbon Hub Task Group considered that a requirement for roof-mounted solar technologies equivalent to 40% of ground floor area is the appropriate reference point for feasibility. If the area required exceeds this amount, other measures may be necessary which are not feasibility or desirable in every case. The majority of participants at the “have your say” events who commented on this issue agreed that this was an appropriate reference point.

Figure C-3: Feasibility: How the 40% Ground floor Area translates into PV area on typical roofs

From: Carbon Compliance: setting an appropriate level for zero-carbon homes: *Zero Carbon Hub* (Feb. 2011 p.14)

C.2.3. The following tables introduce the assumptions for individual case studies for the distribution of residential units per floor, with particular reference to the top floor. This was used to determine the floor area and hence the applicable area for solarPV.

Table C-10: Development Assumptions

** Assume all residential and mixed use buildings comprise of 4 storeys for residential units and have 15 units per building.

Case Study 1	
Number of Flats	15
Total floorspace	1,355 m2
Total floors	4
Number of buildings	1
Gross Intern Area per Floor	338.8
1 bed Flat on top floor	4.0
GEA:GIA ratio 80%	
Gross Extern Area per Floor	423.4
Gross Roof Top Area for Panels (assume 30 degree incline)	486.2

Case Study 3		
Number of Flats	50	
Total floorspace	4,500 m2	
Total floors per building	4	
Number of buildings	4	
Buildings 1 - 3	Units	Floorspace
1bed	4	300
2bed	3	255
3bed	5	525
	12	1080
GIA per floor	GEA per floor (80% efficiency ratio)	
270	337.5	
Top floor units (demand)	3 x 2bed flats	
Gross Roof Top Area for Panels (assume 30 degree incline)	390.1	

Building 4	Units	Floorspace
1bed	3	225
2bed	6	510
3bed	5	525
	14	1260
GIA per floor	GEA per floor	
315	393.75	
Top floor units (demand)	3 x 1bed flats & 1 x 2bed flats	
Gross Roof Top Area for Panels (assume 30 degree incline)	451.4	

C.2.4. The following tables describe the assumptions adopted for the solar PV considerations. For apartments an angle of 30 degrees and for houses an angle of 45 degrees was assumed. Solar PV was assumed to be facing due south for maximum performance. The Romag SMT 6(60)P PV Modules were used as a benchmark.

Table C-11: Solar Photovoltaic Reference Assumptions

Solar PV reference tables

SAP insulation calcs Orientation: all values kWh per year per kWp

Collector tilt (degrees)	South	SE/SW	E/W	NE/NW	North
Horizontal			961		
30	1,073	1,027	913	785	730
45	1,054	997	854	686	640
60	989	927	776	597	500
Vertical	746	705	582	440	371

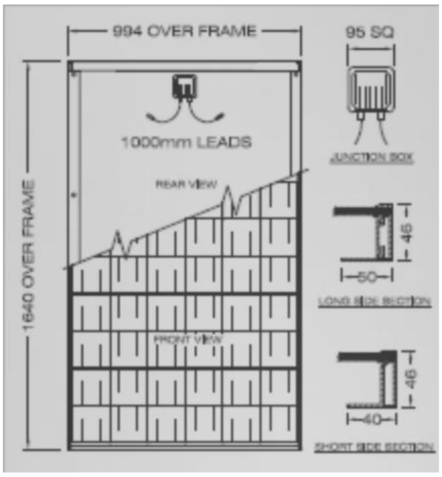
SAP PV output method
0.8 x 1kWp x kWh radiation/m2/yr x panel efficiency x overshading factor

ROMAG SMT 6(60)P PV Modules				
Area	1.63	1	6.94	m2
Capacity	235	144.17	1,000.00	Wp
Efficiency	14.4%			Percent
Cost £	3,000			kWp

Romag SMT 6(60)P Electrical Characteristics

Pmpp	235	230	225	220	Wp
Vmpp	29.47	29.18	29.03	28.70	V
Impp	7.96	7.88	7.76	7.67	A
Voc	37.32	37.07	36.98	36.74	V
Isc	8.45	8.37	8.24	8.18	A
FF	74.41	74.11	73.84	73.18	%
Efficiency	14.4	14.1	13.8	13.5	%

Temperature Characteristics
Coeficients: Power -0.45%/^{0}C Voltage -0.35%/^{0}C Current 0.05%/^{0}C
Module Weight: 21 Kg



C.3. Solar Thermal Hot Water Assumptions:

C.3.1. Solar Thermal technology is used to cater to the thermal requirements of residential units. Solar Thermal technology shares assumptions with Solar Photovoltaic for roof surface area and angle, to optimise use of natural sunlight. The assumptions for calculating the costs for Solar thermal using the Evacuated tube technology and its reduction in carbon (kgCO2) targets has been summarised in Table C-12 below. The STHW reference tables consider the basic assumptions for calculating the installation costs per unit and CO2e saved over gas requirements.

Table C-12: Summary of Solar Thermal Hot Water Technology Assumptions

	Collector area per dwelling unit m2	Total collector area	kWh/yr	kWh/m2/yr	m2 floorspace DHW demand	kgCO2e reduction: total installation	kgCO2 red./m2	Cost £ installation	Cost £/m2 installation
House	4	4	1800	15	118	330	2.8	3,500	29.66
x 4 standard apt top floor	2	8	5400	16	340	991	2.9	13,380.00	39.35

CO2 factors	
Natural gas	0.1836
Grid elec.	0.541

Source: 2011 Guidelines to DEFRA/DECC's GHG Conversion factors for Company Reporting
http://archive.defra.gov.uk/environment/business/reporting/pdf/110819-guidelines-ghg-conversion-factors.pdf

STHW reference tables

	Collector type	kWh/m2/yr	Collector area m2	kWh energy yield/yr	Install cost	CO2e saved (over gas)
House	Evacuated tube	450	4	1800	3,500.00	330.48
Apartment	Evacuated tube	450	3	1350	3,345.00	247.86
Apartment block	Evacuated tube	450	12	5400	13,380.00	991.44

Technology information leaflet ECA 770 *Solar thermal technology*
http://etl.decc.gov.uk/NR/rdonlyres/BEC48F29-FF6C-49B0-BBC3-3263006A26A/0/ECA770_TILSolarThermal.pdf

Appendix D. Viability Case studies

D.1.1. The following section introduces the case study findings from the development appraisal model. The section 3 Viability testing in the technical note introduces the details of the case study which includes the number of unites by type and size. The figures in each column denote the appraisal values in 2011 and subsequent projections in 2013 and 2016 based on 2% CAGR on construction costs and 3% CAGR on sales. The code compliance targets set out below, show that the ones in green satisfy the target for the respective code while the ones in red do not achieve the target and has to be compensated by allowable solutions. All the case studies displayed below are representative of ‘Hot’ markets.

D.1. Case Study 1 (CS1) 15 units Apartments

Case Study	**CS1**		
Market Condition	**HOT**		
	Code 3		
Number of Residential Units	**15**		
	Units		
1 Bed Apartment	4 units		
2 Bed Apartment	5 units		
3+ Bed Apartment	6 units		
2 Bed House	units		
3+ Bed House	units		
Total	**15 units**		
	Floorspace		
1 Bed Apartment	300 m2		
2 Bed Apartment	425 m2		
3+ Bed Apartment	630 m2		
2 Bed House	0 m2		
3+ Bed House	0 m2		
Total	**1,355 m2**		
Affordable Housing Component (%)	**35%**		
Social Rent	**71%**		
Equity Share	**29%**		
	2011	**2013**	**2016**
Increase In Sales Assumed	**0%**		
Gross Development Value	**£2,316,337**	£2,457,402	£2,685,270
Construction Costs	**£1,205,950**	£1,254,670	£1,331,466
Reduction in Cost Assumed	**0%**		
Planning Obligations Costs	**£48,750**	£48,750	£48,750
Fabric Cost of Development	**£16,065**	£16,714	£17,737
Cost of Code for Sustainable Housing	**£15,060**	£15,669	£16,628
Commercial Construction	**£0**	£0	£0
Admin & Prof Fees	**£238,801**	£248,448	£263,656
Construction Contingency	**£60,298**	£62,734	£66,573
Land Acquisition	**£300,000**	£300,000	£300,000
Costs of the Scheme	**£1,884,924**	£1,946,985	£2,044,810
Residual Value	**£431,413**	£510,417	£640,460
Developer's Return	**22.9%**	26.2%	31.3%

	Compliance with Code 3 (base)	Compliance with 2013 Code 4	Compliance with 2016 Code 5	Compliance with 2016 Code 5 ZERO CARBON	Compliance with Code 6 (Hypothetical)
CHP: City Wide Connection	9,234 kg/ CO2 E	7,224 kg/ CO2 E	5,849 kg/ CO2 E	-8,616 kg/ CO2 E	-29,116 kg/ CO2 E
Developer's Return	£72,532	(BASED ON 2.0% CAGR ON CONSTRUCTION & 3.0% CAGR ON SALES)			
Developer's Return (%)	19.0%	22.5%	27.8%	27.8%	27.8%
CHP: Scheme	0 kg/ CO2 E	-2,010 kg/ CO2 E	-3,385 kg/ CO2 E	-17,850 kg/ CO2 E	-38,350 kg/ CO2 E
Developer's Return	£0	(BASED ON 2.0% CAGR ON CONSTRUCTION & 3.0% CAGR ON SALES)			
Developer's Return (%)	22.9%	26.2%	31.3%	31.3%	31.3%
PV & Solar Thermal	37,645 kg/ CO2 E	33,625 kg/ CO2 E	30,876 kg/ CO2 E	1,945 kg/ CO2 E	-39,054 kg/ CO2 E
Developer's Return	£286,523	(BASED ON 2.0% CAGR ON CONSTRUCTION & 3.0% CAGR ON SALES)			
Developer's Return (%)	7.7%	11.5%	17.3%	17.3%	17.3%

Allowable Solutions (to reach Zero Carbon)	
CHP: City Wide Connection	£25,849
CHP: Scheme	£53,550
PV & Solar Thermal	£0

Viability - CfSH + Renewable Tech + Allowable Solution			
CHP: City Wide Connection	17.7%	21.2%	26.5%
CHP: Scheme	20.0%	23.5%	28.7%
PV & Solar Thermal	7.7%	11.5%	17.3%

Allowable Solutions ONLY for unviable schemes	£58,410 19.8%

D.2. Case Study 2 (CS2) 15 units Housing

Case Study	**CS2**		
Market Condition	**HOT**		
	Code 3		
Number of Residential Units	**15**		
	Units		
1 Bed Apartment	units		
2 Bed Apartment	units		
3+ Bed Apartment	units		
2 Bed House	7 units		
3+ Bed House	8 units		
Total	**15 units**		
	Floorspace		
1 Bed Apartment	0 m2		
2 Bed Apartment	0 m2		
3+ Bed Apartment	0 m2		
2 Bed House	770 m2		
3+ Bed House	1,000 m2		
Total	**1,770 m2**		
Affordable Housing Component (%)	**35%**		
Social Rent	**71%**		
Equity Share	**29%**		
	2011	**2013**	**2016**
Increase In Sales Assumed	**0%**		
Gross Development Value	**£3,020,078**	£3,204,001	£3,501,098
Construction Costs	**£1,296,758**	£1,349,147	£1,431,725
Reduction in Cost Assumed	**0%**		
Planning Obligations Costs	**£48,750**	£48,750	£48,750
Fabric Cost of Development	**£30,755**	£31,998	£33,956
Cost of Code for Sustainable Housing	**£18,695**	£19,451	£20,641
Commercial Construction	**£0**	£0	£0
Admin & Prof Fees	**£279,187**	£290,466	£308,245
Construction Contingency	**£67,895**	£70,638	£74,961
Land Acquisition	**£600,000**	£600,000	£600,000
Costs of the Scheme	**£2,342,040**	£2,410,449	£2,518,279
Residual Value	**£678,038**	**£793,552**	**£982,819**
Developer's Return	**29.0%**	**32.9%**	**39.0%**

	Compliance with Code 3 (base)	Compliance with 2013 Code 4	Compliance with 2016 Code 5	Compliance with 2016 Code 5 ZERO CARBON	Compliance with Code 6 (Hypothetical)
CHP: City Wide Connection	11,552 kg/ CO2 E	7,851 kg/ CO2 E	2,599 kg/ CO2 E	-7,918 kg/ CO2 E	-39,720 kg/ CO2 E
Developer's Return	£102,863	(BASED ON 2.0% CAGR ON CONSTRUCTION & 3.0% CAGR ON SALES)			
Developer's Return (%)	24.6%	28.7%	34.9%	34.9%	34.9%
CHP: Scheme	0 kg/ CO2 E	-3,701 kg/ CO2 E	-8,953 kg/ CO2 E	-19,470 kg/ CO2 E	-51,272 kg/ CO2 E
Developer's Return	£0	(BASED ON 2.0% CAGR ON CONSTRUCTION & 3.0% CAGR ON SALES)			
Developer's Return (%)	29.0%	32.9%	39.0%	39.0%	39.0%
PV & Solar Thermal	27,442 kg/ CO2 E	20,041 kg/ CO2 E	9,537 kg/ CO2 E	-11,498 kg/ CO2 E	-75,102 kg/ CO2 E
Developer's Return	£200,550	(BASED ON 2.0% CAGR ON CONSTRUCTION & 3.0% CAGR ON SALES)			
Developer's Return (%)	20.4%	24.6%	31.1%	31.1%	31.1%

Allowable Solutions (to reach Zero Carbon)	
CHP: City Wide Connection	£23,755
CHP: Scheme	£58,410
PV & Solar Thermal	£34,493

Viability - CfSH + Renewable Tech + Allowable Solution			
CHP: City Wide Connection	23.5%	27.7%	34.0%
CHP: Scheme	26.5%	30.5%	36.7%
PV & Solar Thermal	18.9%	23.2%	29.7%

Allowable Solutions ONLY for unviable schemes	£53,550 26.7%

D.3. Case Study 3 (CS3) 50 units Apartments

Case Study	**CS3**		
Market Condition	**HOT**		
	Code 3		
Number of Residential Units	**50**		
	Units		
1 Bed Apartment	15 units		
2 Bed Apartment	15 units		
3+ Bed Apartment	20 units		
2 Bed House	units		
3+ Bed House	units		
Total	**50 units**		
	Floorspace		
1 Bed Apartment	1,125 m2		
2 Bed Apartment	1,275 m2		
3+ Bed Apartment	2,100 m2		
2 Bed House	0 m2		
3+ Bed House	0 m2		
Total	**4,500 m2**		
Affordable Housing Component (%)	**35%**		
Social Rent	**71%**		
Equity Share	**29%**		
	2011	**2013**	**2016**
Increase In Sales Assumed	**0%**		
Gross Development Value	**£7,694,183**	£8,162,759	£8,919,667
Construction Costs	**£4,005,000**	£4,166,802	£4,421,844
Reduction in Cost Assumed	**0%**		
Planning Obligations Costs	**£162,500**	£162,500	£162,500
Fabric Cost of Development	**£53,550**	£55,713	£59,124
Cost of Code for Sustainable Housing	**£70,488**	£73,335	£77,824
Commercial Construction	**£0**	£0	£0
Admin & Prof Fees	**£818,605**	£851,676	£903,806
Construction Contingency	**£208,750**	£217,184	£230,477
Land Acquisition	**£625,000**	£625,000	£625,000
Costs of the Scheme	**£5,943,892**	£6,152,211	£6,480,574
Residual Value	**£1,750,291**	£2,010,548	£2,439,093
Developer's Return	29.4%	32.7%	37.6%

	Compliance with Code 3 (base)	**Compliance with 2013 Code 4**	**Compliance with 2016 Code 5**	**Compliance with 2016 Code 5 ZERO CARBON**	**Compliance with Code 6 (Hypothetical)**
CHP: City Wide Connection	30,666 kg/ CO2 E	23,965 kg/ CO2 E	19,383 kg/ CO2 E	-28,834 kg/ CO2 E	-97,167 kg/ CO2 E
Developer's Return	£240,882	(BASED ON 2.0% CAGR ON CONSTRUCTION & 3.0% CAGR ON SALES)			
Developer's Return (%)	25.4%	28.8%	33.9%	33.9%	33.9%
CHP: Scheme	0 kg/ CO2 E	-6,700 kg/ CO2 E	-11,282 kg/ CO2 E	-59,500 kg/ CO2 E	-127,832 kg/ CO2 E
Developer's Return	£0	(BASED ON 2.0% CAGR ON CONSTRUCTION & 3.0% CAGR ON SALES)			
Developer's Return (%)	29.4%	32.7%	37.6%	37.6%	37.6%
PV & Solar Thermal	125,483 kg/ CO2 E	112,083 kg/ CO2 E	102,919 kg/ CO2 E	6,483 kg/ CO2 E	-130,181 kg/ CO2 E
Developer's Return	£951,551	(BASED ON 2.0% CAGR ON CONSTRUCTION & 3.0% CAGR ON SALES)			
Developer's Return (%)	13.4%	17.2%	23.0%	23.0%	23.0%

Allowable Solutions (to reach Zero Carbon)	
CHP: City Wide Connection	£86,503
CHP: Scheme	£178,500
PV & Solar Thermal	£0

Viability - CfSH + Renewable Tech + Allowable Solution			
CHP: City Wide Connection	23.9%	27.4%	32.6%
CHP: Scheme	26.4%	29.8%	34.9%
PV & Solar Thermal	13.4%	17.2%	23.0%

Allowable Solutions ONLY for unviable schemes	£194,700
	26.2%

D.4. Case Study 4 (CS4) 50 units Housing

Case Study	**CS4**		
Market Condition	**HOT**		
	Code 3		
Number of Residential Units	**50**		
	Units		
1 Bed Apartment	units		
2 Bed Apartment	units		
3+ Bed Apartment	units		
2 Bed House	25 units		
3+ Bed House	25 units		
Total	**50 units**		
	Floorspace		
1 Bed Apartment	0 m2		
2 Bed Apartment	0 m2		
3+ Bed Apartment	0 m2		
2 Bed House	2,750 m2		
3+ Bed House	3,125 m2		
Total	**5,875 m2**		
Affordable Housing Component (%)	**35%**		
Social Rent	**71%**		
Equity Share	**29%**		
	2011	**2013**	**2016**
Increase In Sales Assumed	**0%**		
Gross Development Value	**£10,038,101**	**£10,649,421**	£11,636,910
Construction Costs	**£4,304,211**	**£4,478,101**	£4,752,196
Reduction in Cost Assumed	**0%**		
Planning Obligations Costs	**£162,500**	**£162,500**	£162,500
Fabric Cost of Development	**£102,517**	**£106,658**	£113,187
Cost of Code for Sustainable Housing	**£77,677**	**£80,815**	£85,762
Commercial Construction	**£0**	**£0**	£0
Admin & Prof Fees	**£932,734**	**£970,417**	£1,029,814
Construction Contingency	**£227,261**	**£236,442**	£250,914
Land Acquisition	**£1,437,500**	**£1,437,500**	£1,437,500
Costs of the Scheme	**£7,244,399**	**£7,472,433**	**£7,831,873**
Residual Value	**£2,793,702**	**£3,176,988**	**£3,805,038**
Developer's Return	**38.6%**	**42.5%**	**48.6%**

	Compliance with Code 3 (base)	**Compliance with 2013 Code 4**	**Compliance with 2016 Code 5**	**Compliance with 2016 Code 5 ZERO CARBON**	**Compliance with Code 6 (Hypothetical)**
CHP: City Wide Connection	**38,343 kg/ CO2 E**	**26,006 kg/ CO2 E**	**8,500 kg/ CO2 E**	**-26,557 kg/ CO2 E**	**-132,564 kg/ CO2 E**
Developer's Return	**£341,422**	(BASED ON 2.0% CAGR ON CONSTRUCTION & 3.0% CAGR ON SALES)			
Developer's Return (%)	**33.9%**	**37.9%**	**44.2%**	**44.2%**	**44.2%**
CHP: Scheme	**0 kg/ CO2 E**	**-12,336 kg/ CO2 E**	**-29,843 kg/ CO2 E**	**-64,900 kg/ CO2 E**	**-170,907 kg/ CO2 E**
Developer's Return	**£0**	(BASED ON 2.0% CAGR ON CONSTRUCTION & 3.0% CAGR ON SALES)			
Developer's Return (%)	**38.6%**	**42.5%**	**48.6%**	**48.6%**	**48.6%**
PV & Solar Thermal	**91,475 kg/ CO2 E**	**66,802 kg/ CO2 E**	**31,789 kg/ CO2 E**	**-38,325 kg/ CO2 E**	**-250,339 kg/ CO2 E**
Developer's Return	**£665,667**	(BASED ON 2.0% CAGR ON CONSTRUCTION & 3.0% CAGR ON SALES)			
Developer's Return (%)	**29.4%**	**33.6%**	**40.1%**	**40.1%**	**40.1%**

Allowable Solutions (to reach Zero Carbon)	
CHP: City Wide Connection	**£79,672**
CHP: Scheme	**£194,700**
PV & Solar Thermal	**£114,976**

Viability - CfSH + Renewable Tech + Allowable Solution			
CHP: City Wide Connection	**32.8%**	**36.9%**	**43.2%**
CHP: Scheme	**35.9%**	**39.9%**	**46.1%**
PV & Solar Thermal	**27.8%**	**32.1%**	**38.6%**

Allowable Solutions ONLY for unviable schemes	
	£178,500
	36.1%

D.5. Case Study 5 (CS5) 200 units Mixed residential

Case Study	**CS5**		
Market Condition	**HOT**		
	Code 3		
Number of Residential Units	**200**		
	Units		
1 Bed Apartment	35 units		
2 Bed Apartment	40 units		
3+ Bed Apartment	40 units		
2 Bed House	40 units		
3+ Bed House	45 units		
Total	**200 units**		
	Floorspace		
1 Bed Apartment	2,625 m2		
2 Bed Apartment	3,400 m2		
3+ Bed Apartment	4,200 m2		
2 Bed House	4,400 m2		
3+ Bed House	5,625 m2		
Total	**20,250 m2**		
Affordable Housing Component (%)	**35%**		
Social Rent	**71%**		
Equity Share	**29%**		
	2011	**2013**	**2016**
Increase In Sales Assumed	**0%**		
Gross Development Value	**£34,699,559**	**£36,812,762**	£40,226,299
Construction Costs	**£16,444,882**	**£17,109,255**	£18,156,478
Reduction in Cost Assumed	**0%**		
Planning Obligations Costs	**£650,000**	**£650,000**	£650,000
Fabric Cost of Development	**£297,443**	**£309,460**	£328,401
Cost of Code for Sustainable Housing	**£378,112**	**£393,387**	£417,466
Commercial Construction	**£0**	**£0**	£0
Admin & Prof Fees	**£3,452,016**	**£3,591,478**	£3,811,305
Construction Contingency	**£861,509**	**£896,314**	£951,176
Land Acquisition	**£3,737,500**	**£3,737,500**	£3,737,500
Costs of the Scheme	**£25,821,462**	**£26,687,394**	**£28,052,326**
Residual Value	**£8,878,097**	**£10,125,368**	**£12,173,974**
Developer's Return	**34.4%**	**37.9%**	**43.4%**

	Compliance with Code 3 (base)	**Compliance with 2013 Code 4**	**Compliance with 2016 Code 5**	**Compliance with 2016 Code 5 ZERO CARBON**	**Compliance with Code 6 (Hypothetical)**
CHP: City Wide Connection	**135,106 kg/ CO2 E**	**98,724 kg/ CO2 E**	**58,424 kg/ CO2 E**	**-112,074 kg/ CO2 E**	**-449,449 kg/ CO2 E**
Developer's Return	**£1,129,935**	(BASED ON 2.0% CAGR ON CONSTRUCTION & 3.0% CAGR ON SALES)			
Developer's Return (%)	**30.0%**	**33.7%**	**39.4%**	**39.4%**	**39.4%**
CHP: Scheme	**121,979 kg/ CO2 E**	**85,596 kg/ CO2 E**	**45,296 kg/ CO2 E**	**-125,201 kg/ CO2 E**	**-462,577 kg/ CO2 E**
Developer's Return	**£1,335,656**	(BASED ON 2.0% CAGR ON CONSTRUCTION & 3.0% CAGR ON SALES)			
Developer's Return (%)	**29.2%**	**32.9%**	**38.6%**	**38.6%**	**38.6%**
PV & Solar Thermal	**444,119 kg/ CO2 E**	**371,354 kg/ CO2 E**	**290,754 kg/ CO2 E**	**-50,241 kg/ CO2 E**	**-724,992 kg/ CO2 E**
Developer's Return	**£3,298,020**	(BASED ON 2.0% CAGR ON CONSTRUCTION & 3.0% CAGR ON SALES)			
Developer's Return (%)	**21.6%**	**25.6%**	**31.6%**	**31.6%**	**31.6%**

Allowable Solutions (to reach Zero Carbon)	
CHP: City Wide Connection	**£336,221**
CHP: Scheme	**£375,604**
PV & Solar Thermal	**£150,724**

Viability - CfSH + Renewable Tech + Allowable Solution			
CHP: City Wide Connection	**28.7%**	**32.4%**	**38.2%**
CHP: Scheme	**27.8%**	**31.5%**	**37.3%**
PV & Solar Thermal	**21.0%**	**25.0%**	**31.1%**

Allowable Solutions ONLY for unviable schemes	**£751,260**
	31.5%

D.6. Case Study 6 (CS6) 500 units Mixed residential

Case Study	**CS6**		
Market Condition	**HOT**		
	Code 3		
Number of Residential Units	**500**		
	Units		
1 Bed Apartment	75 units		
2 Bed Apartment	100 units		
3+ Bed Apartment	125 units		
2 Bed House	100 units		
3+ Bed House	100 units		
Total	**500 units**		
	Floorspace		
1 Bed Apartment	5,625 m2		
2 Bed Apartment	8,500 m2		
3+ Bed Apartment	13,125 m2		
2 Bed House	11,000 m2		
3+ Bed House	12,500 m2		
Total	**50,750 m2**		
Affordable Housing Component (%)	**35%**		
Social Rent	**71%**		
Equity Share	**29%**		
	2011	**2013**	**2016**
Increase In Sales Assumed	**0%**		
Gross Development Value	**£86,640,802**	**£91,917,226**	£100,440,435
Construction Costs	**£41,469,342**	**£43,144,704**	£45,785,505
Reduction in Cost Assumed	**0%**		
Planning Obligations Costs	**£1,625,000**	**£1,625,000**	£1,625,000
Fabric Cost of Development	**£731,367**	**£760,914**	£807,488
Cost of Code for Sustainable Housing	**£953,019**	**£991,521**	£1,052,210
Commercial Construction	**£0**	**£0**	£0
Admin & Prof Fees	**£8,678,696**	**£9,029,316**	£9,581,982
Construction Contingency	**£2,170,892**	**£2,258,596**	£2,396,840
Land Acquisition	**£7,412,500**	**£7,412,500**	£7,412,500
Costs of the Scheme	**£63,040,816**	**£65,222,550**	**£68,661,525**
Residual Value	**£23,599,985**	**£26,694,676**	**£31,778,910**
Developer's Return	**37.4%**	**40.9%**	**46.3%**

	Compliance with Code 3 (base)	**Compliance with 2013 Code 4**	**Compliance with 2016 Code 5**	**Compliance with 2016 Code 5 ZERO CARBON**	**Compliance with Code 6 (Hypothetical)**
CHP: City Wide Connection	339,068 kg/ CO2 E	249,521 kg/ CO2 E	152,002 kg/ CO2 E	-277,532 kg/ CO2 E	-1,111,552 kg/ CO2 E
Developer's Return	**£2,824,365**	(BASED ON 2.0% CAGR ON CONSTRUCTION & 3.0% CAGR ON SALES)			
Developer's Return (%)	**33.0%**	**36.6%**	**42.2%**	**42.2%**	**42.2%**
CHP: Scheme	305,775 kg/ CO2 E	216,229 kg/ CO2 E	118,709 kg/ CO2 E	-310,825 kg/ CO2 E	-1,144,845 kg/ CO2 E
Developer's Return	**£3,335,554**	(BASED ON 2.0% CAGR ON CONSTRUCTION & 3.0% CAGR ON SALES)			
Developer's Return (%)	**32.1%**	**35.8%**	**41.4%**	**41.4%**	**41.4%**
PV & Solar Thermal	1,118,799 kg/ CO2 E	939,706 kg/ CO2 E	744,667 kg/ CO2 E	-114,401 kg/ CO2 E	-1,782,441 kg/ CO2 E
Developer's Return	**£8,424,842**	(BASED ON 2.0% CAGR ON CONSTRUCTION & 3.0% CAGR ON SALES)			
Developer's Return (%)	**24.1%**	**28.0%**	**34.0%**	**34.0%**	**34.0%**

Allowable Solutions (to reach Zero Carbon)	
CHP: City Wide Connection	**£832,597**
CHP: Scheme	**£932,475**
PV & Solar Thermal	**£343,204**

Viability - CfSH + Renewable Tech + Allowable Solution			
CHP: City Wide Connection	**31.6%**	**35.3%**	**41.0%**
CHP: Scheme	**30.7%**	**34.4%**	**40.1%**
PV & Solar Thermal	**23.5%**	**27.5%**	**33.5%**

Allowable Solutions ONLY for unviable schemes	
	£1,882,200
	34.5%

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