Costs of building to the Code for Sustainable Homes

September 2013

Bath & North East Somerset Council · Brighton & Hove City Council · Bristol City Council · Swindon Borough Council · Working in partnership with Wiltshire Council Where everybody matters

Summary

This report summarises the results of a study into the costs of building new dwellings to the Code for Sustainable Homes conducted in September 2013.[1] The work was commissioned by a group of local authorities[2] and builds on previous research undertaken by Element Energy and Davis Langdon on behalf of the Department of Communities and Local Government.[3] The key findings are:

- Overall costs of building to the Code have reduced over the past few years. For example, per dwelling costs of meeting CSH5 have fallen from a range of £16.5k–23k in the 2011 study to £6.5k–10.5k today (a reduction of around 55%). The equivalent range for CSH6 is £28k–38k in the 2011 study to £15k–26k today (a c.40% decrease).

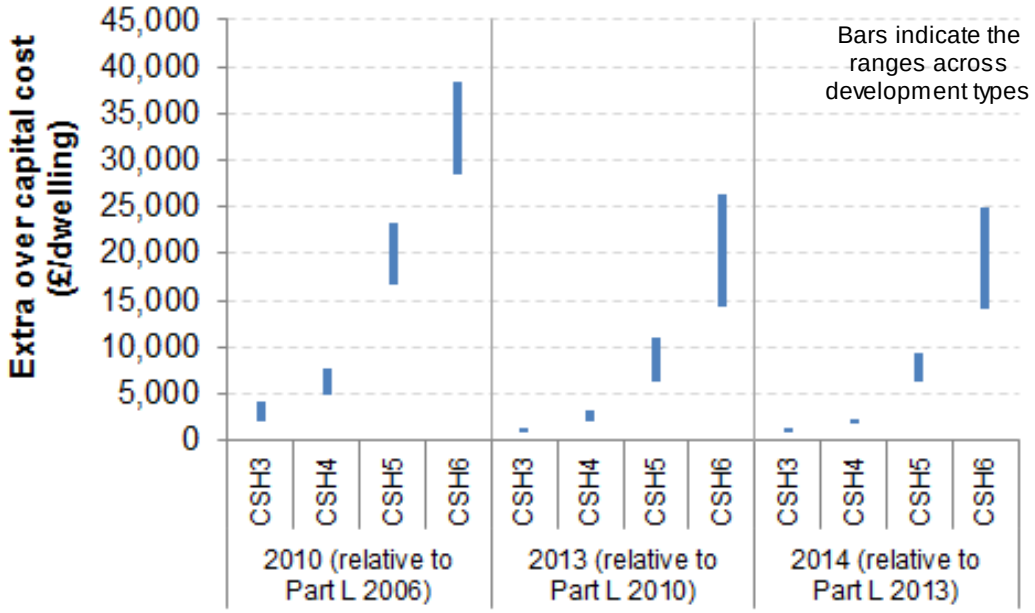


Figure 1: Range of total extra over costs of meeting Code levels 3 to 6 for each development scenario (average per dwelling) based on the least cost energy strategies

- The principal driver of the cost reductions at the higher Code levels is the reduction in capital cost of photovoltaics (a technology that features highly in energy strategies that meet the mandatory

[1] Data behind the charts presented in this report are provided in the accompanying spreadsheet.
[2] Bath & North East Somerset Council, Brighton & Hove City Council, Bristol City Council, Swindon Borough Council, and Wiltshire Council.
[3] *Costs of building to the Code for Sustainable Homes: Updated cost review*, DCLG (August 2011).

CO_2 emission reduction requirement). The latest cost data suggest that total installed costs of PV systems at the scales relevant for dwellings have fallen by >60% over the past few years.

- A secondary factor that has decreased the *extra over cost* of building Code homes is the tightening of Part L of the Building Regulations in 2010. This change means there is no additional cost in meeting the mandatory CO_2 reduction requirement of CSH3, for example.
- Future revisions to Part L will further reduce the extra over cost of building to the Code. In particular, the introduction of zero carbon homes legislation (Part L 2016), which is expected to require all regulated emissions to be abated (likely to be via a combination of on-site and off-site measures).
- Achieving CSH6 remains a challenge, both in technical and in cost terms. This study's results suggest that at least a 25% cost premium (over base build costs) is faced by developers building Code level 6 homes. Experience in building to this level of the Code remains very limited, with 233 Code 6 post-construction certificates issued nationally over a five year period to the end of March 2013.
- The challenges of building to the highest level of the Code are largely due to the requirement to achieve net zero CO_2 emissions (including unregulated emissions).
- The introduction of allowable solutions to the Code could significantly improve the technical and economic viability of achieving CSH6. For example, based on an allowable solutions (AS) price of £60/tCO_2, the costs of building to level 6 could be as low as £8.5k–13.5k/dwelling. Similarly, with AS, the total extra over costs of building to Code level 5 could fall to £5.5k–9.2k/dwelling.
- The costs of building to CSH5 (of the order £6.5k–10.5k per dwelling) represent an increase of around 10–15% on base build costs. The fall in costs of PV mean that an energy strategy with improved fabric, a high efficiency gas boiler, and PV is now a viable option at Code level 5 (given sufficient roof space). The previous study's results showed a high reliance on biomass to meet the mandatory emission reductions needed in cost-effective energy strategies at this level.
- Total costs of building to the Code continue to be dominated by the mandatory CO_2 emission reduction requirement. For example, costs against the Energy category are typically 50% of the total costs at levels 4 and 5, rising to c.80% at level 6. Meeting the mandatory target for internal water consumption can be another significant cost, e.g. around a quarter of the total cost at Code level 5. This may be higher still if rainwater harvesting technology does not give the required reduction (<80 litres per person per day), and alternative solutions (e.g. greywater recycling) are needed. This issue is likely to be dwelling-specific as it depends on the specification of other water-related features.
- Community energy solutions with district heating are most suited to large scale, high density sites. For example, this study's modelling suggests that community biomass boilers may be the most cost-effective solution for meeting CSH6 for the *Urban regeneration* development.[4]
- The continued fall in PV costs is likely to favour dwelling-scale energy approaches over community heating. This is reflected by the fact that district heating based energy systems do not provide the most cost-effective approach to CSH5 in any of the development types considered.

[4] Note that while the costs of community heating energy strategies in this study are based on representative data, costs of such schemes are highly site-specific. The case for district heating should therefore be assessed on a site-by-site basis where possible, in the context of other strategic drivers for community energy approaches (e.g. seeding a network of low carbon heat supply that could be used to decarbonise neighbouring existing buildings).

Note however that this study focuses on residential development only; the viability of district heating is closely linked to overall heat density (which in many cases will be influenced by non-residential demands) and should be considered on a site-by-site basis.[5]

Introduction

Background

The Code for Sustainable Homes is the UK's national standard for sustainable construction of new dwellings and has now been in place for over five years, in which time over 110,000 homes have been built to the Code (see Figure 2). Element Energy and Davis Langdon previously undertook research into the costs of building to the Code for the Department of Communities and Local Government. The work was carried out in 2010/11 and published in August 2011.[6]

Changes over the past 2–3 years, in particular revisions to Building Regulations and significant reductions in the price of photovoltaics, mean it is now timely to reassess the costs of building to the Code. A group of local authorities, led by Bath & North East Somerset Council (and including Brighton & Hove City Council, Bristol City Council, Swindon Borough Council, and Wiltshire Council), commissioned Element Energy and Davis Langdon to update the cost assessment in August 2013.

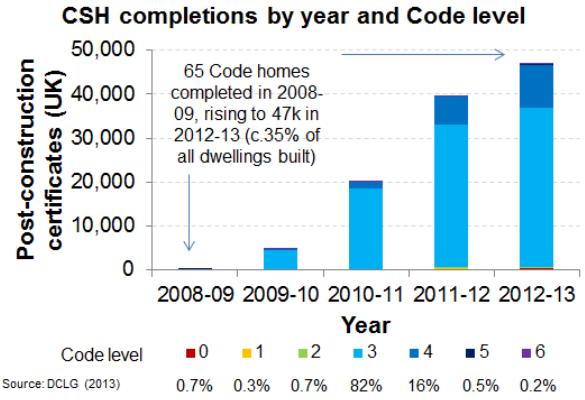


Figure 2: Post construction CSH certificates issued by year

Objectives

The primary objectives of this study include:

- Reassess the costs of building to the Code for Sustainable Homes, in particular levels 4, 5 and 6.
- Update the energy modelling to take account of the revised (and evolving) Building Regulations, i.e. Part L (conservation of fuel and power). Explore how the costs may change over time following the introduction of tighter mandatory standards.
- Evaluate the potential impact on costs of alignment between the highest Code levels and future revisions to Part L – i.e. the introduction of allowable solutions.
- Test the sensitivity of costs to the approach to meeting mandatory emission reduction targets (Ene1), and hence establish the lowest cost energy strategies for five representative site types.

[5] This study focuses on the most cost-effective energy strategies based on capital costs only. On-going costs (and the impact of support schemes such as the feed-in tariff or renewable heat incentive) have not been considered.

[6] *Cost of building to the Code for Sustainable Homes, Updated cost review*, Element Energy and Davis Langdon for DCLG, August 2011.

Dwelling and development types

The dwelling and development types used in the cost assessment are taken from the previous (2011) study, and are designed to be representative of typical mass market developments.

Development scenario	Type*	Scale (no. of dwellings)	Indicative density (dwellings/ha)	Dwelling mix (% of total dwellings)			
				Two-bed flat	Two-bed terrace	Three-bed semi	Four-bed detached
Small brownfield	B	20	40–50	0%	40%	40%	20%
City infill	B	40	150+	100%	0%	0%	0%
Edge of town	G	100	40–50	24%	30%	30%	16%
Strategic greenfield	G	2,000	40–50	20%	30%	30%	20%
Urban regeneration	B	2,000	150+	70%	20%	5%	5%

* B = Brownfield, G = Greenfield

Cost of building to the Code – results

Average extra over costs by Code level and development type

The graph below show the range of total extra over costs of building to the Code (average per dwelling, across the development types) from this study's results compared against the previous (2011) study's findings.

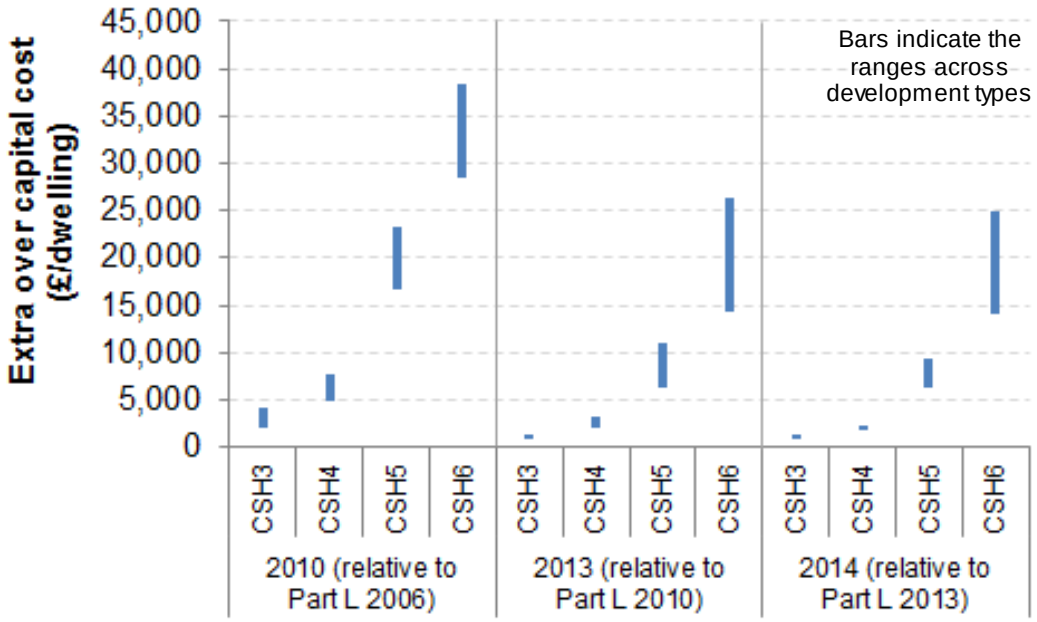


Figure 3: Range of total extra over costs of meeting Code levels 3 to 6 for each development scenario (average per dwelling) based on the least cost energy strategies [7]

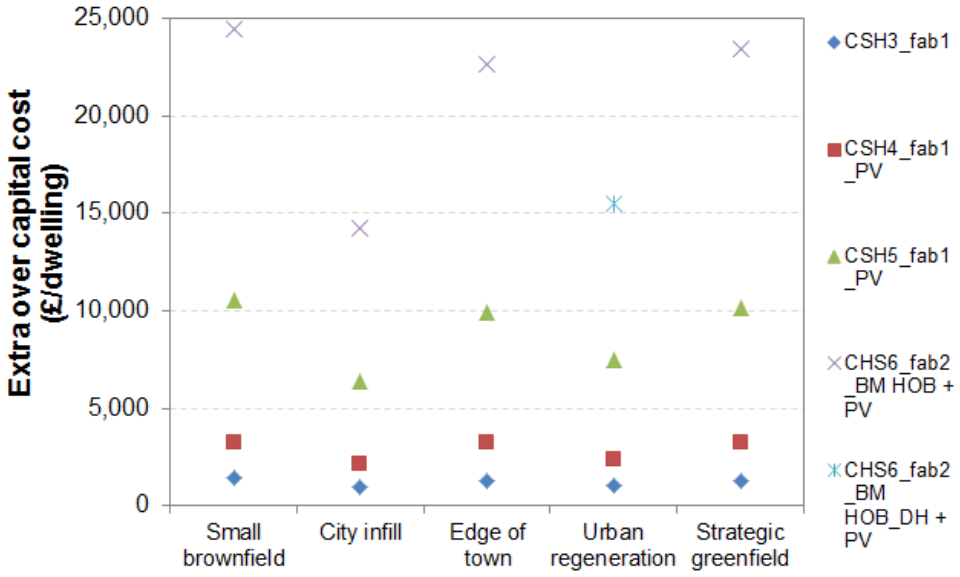
The change in baseline and reduction in PV costs has led to a fall in E/O costs to meet each Code level. For example, the results above suggest meeting CSH4 will cost c.£2–2.5k/dwelling relative to Part L 2013 (compared to around £5k/dwelling relative to Part L 2006 (from the previous study)).

The lowest cost method of achieving CSH5 is now typically based on a strategy with gas boiler with PV (compared to biomass-based approaches).[8]

[7] At the time of writing the details of Part L 2013 were being finalised. For the purposes of this study Part L 2013 is assumed to require emission reductions differentiated by building type to give an overall 6% improvement on 2010 standards. This assumption is based on the summary in DCLG's impact assessment on changes to Part L, published on 08/08/13.
https://www.gov.uk/government/publications/changes-to-part-l-of-the-building-regulations

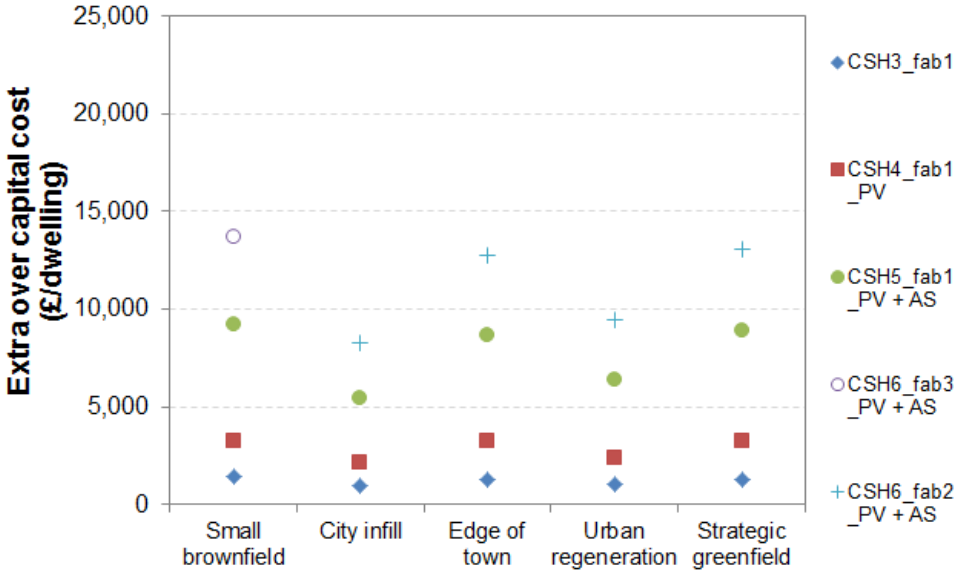
[8] For the purposes of this study's modelling no constraint is placed on the capacity of PV system that could be installed by dwelling type. At the higher Code levels (5 and 6) the capacity of PV needed to meet the mandatory emission reduction targets can become high – e.g. up to 3.6kW$_p$ per flat and 6kW$_p$ per house at Code level 6 in the example above. Roof area constraints (i.e. finding unconstrained, suitably orientated area to install such capacity) may mean that PV-led energy strategies are not practical on all sites (particularly for high density development). As a minimum, this highlights the need to tailor designs to accommodate large renewable energy systems – e.g. through the use of mono-pitched roofs.

Allowable solutions (AS) are the proposed method of facilitating mass-market delivery of zero carbon buildings. While AS are not currently in the Code for Sustainable Homes, there is a reasonable possibility that future changes will lead to their inclusion (in order to maintain alignment between Ene 1 and Part L). The graphs below show the costs of meeting each Code level with and without AS at levels 5 and 6.



Average total extra over cost by Code level – **excluding AS**

Figure 4: Total extra over costs of meeting Code levels 3 to 6 for each development scenario (average per dwelling) based on the least cost energy strategy excluding allowable solutions – relative to Part L 2013 baseline



Average total extra over cost by Code level – **including AS**

Figure 5: Total extra over costs of meeting Code levels 3 to 6 for each development scenario (average per dwelling) based on the least cost energy strategy including allowable solutions – relative to Part L 2013 baseline

These results suggest that inclusion of AS (at £60/tCO_2) could lead to capital cost reductions of c.£1k/dwelling for CSH5 and £6–10k/dwelling for CSH6. The costs of the AS included in the results above are summarised below.

	Two-bed flat	Two-bed terrace	Three-bed semi	Four-bed detached
Carbon compliance level ($kgCO_2/m^2/yr$)[9]	14	11	11	10
Cost of AS at CSH5 (£/dwelling)	1,540	1,445	1,740	2,125
Cost of AS at CSH6 (£/dwelling)	3,710	3,940	4,580	5,480

The cost of allowable solutions is an assumption at this point as the details of the mechanism remain under development. This assumption is discussed further below.

Costs by category

Achieving a Code rating involves addressing a number of mandatory issues (e.g. reductions in CO_2 emissions and internal water consumption), and then implementing measures to score credits against remaining topics. Credits are weighted by category and translated into points, which are summed to provide an overall score. The total percentage points score (TPPS) required increases with Code level sought.

This study's results are based on the assumption that developers seek the lowest cost means of reaching any given Code level and the cost modelling uses the following logic:

- Implement measures to achieve the mandatory credits (Ene 1, Wat 1, Hea 4 (at level 6)).
- Target any zero cost credits in each category.
- Implement measures on an ascending £/point basis until the target TPPS has been met.

The results below show the breakdown of costs by category for a typical dwelling and development example.

[9] Source: *Zero Carbon Strategies for tomorrow's new homes*, Zero Carbon Hub, p.7, (February 2013).

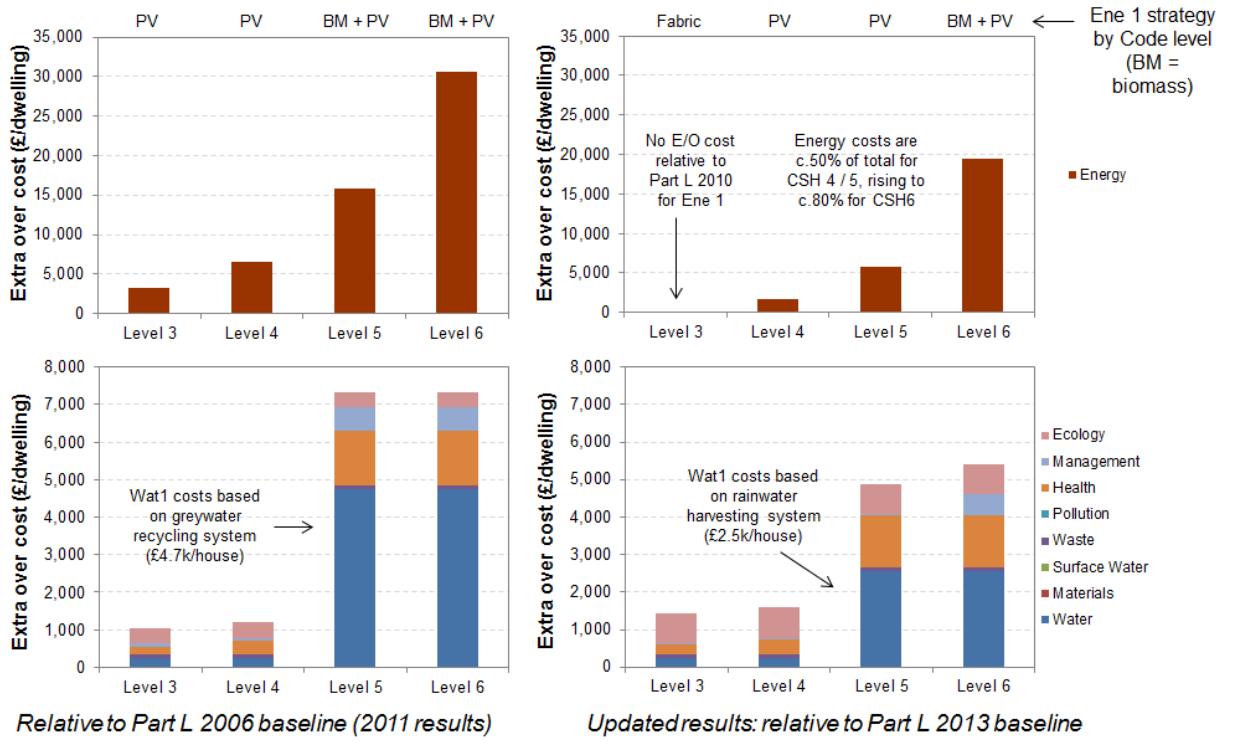


Figure 6: Extra over costs by category at Code levels 3 to 6 for the three-bed semi in a small brownfield development (based on the least cost energy strategy excluding allowable solutions)

The total costs of building to the Code are dominated by the mandatory CO_2 emission reduction requirement (issue Ene 1). While there are nine separate *issues* within the Energy category of the Code, the *Energy* costs presented above are dominated by the costs of the energy strategy employed (which covers issues Ene 1, 2 and 7).

Costs of energy strategies to meet mandatory CO_2 emission reduction targets

The costs by category results above highlight the importance of the energy strategy in determining the overall cost of building to the Code. In general there are many options available to meet both a development's energy demands and the required CO_2 emission reductions. Any energy strategy is likely to involve some level of building fabric improvement (to reduce energy demands), along with a primary heating technology (which may be individual to the dwelling or a community system), and possibly some on-site renewable energy generation. While various factors may influence the choice of energy strategy, capital cost is likely to be a key driver.

The graph below compares the capital costs of alternative energy strategies by Code level and dwelling type.[10] These results are for the *Urban regeneration* site but are not specific to this development as they are based on dwelling-scale energy strategies (as opposed to community heating).

[10] Costs are presented for a selection of approaches to meeting energy demands and emission reduction targets. Other technologies are available and the most appropriate energy strategy is likely to be development-specific.

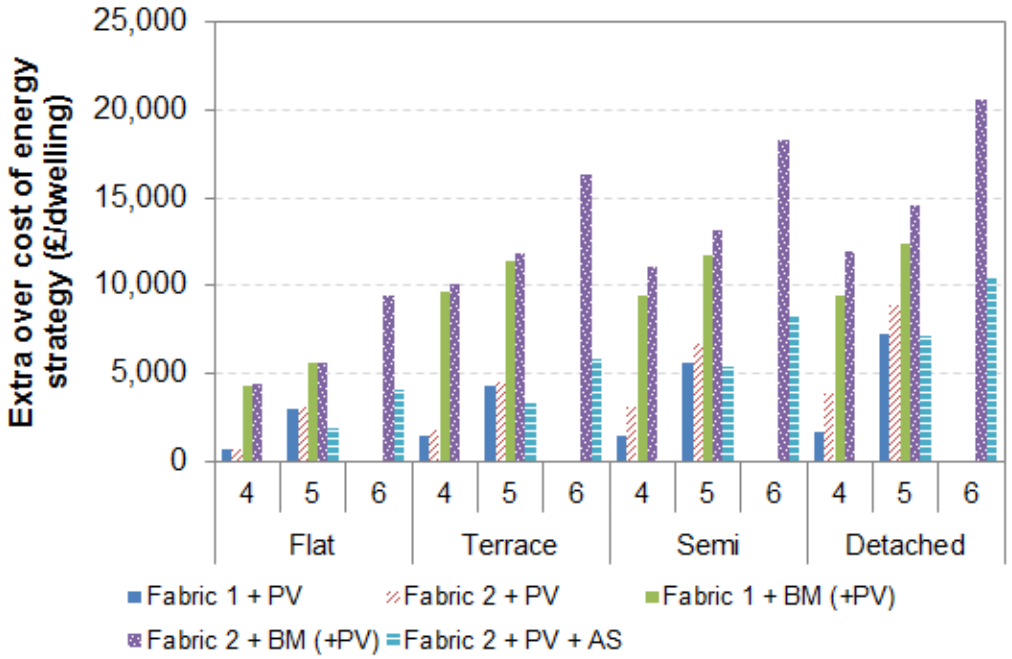


Figure 7: Extra over cost of meeting mandatory Ene 1 criteria for a range of dwelling-scale energy strategies (relative to Part L 2010) – Urban regeneration site (PV = photovoltaics, BM = biomass, AS = allowable solutions)

The costs of the energy strategies above involving allowable solutions are calculated based on emissions over a thirty year period and an AS price of £60/tCO_2. There remains considerable uncertainty regarding how allowable solutions will be implemented, including the potential costs of mitigating emissions in this way. The assumptions used here are taken from the *Central Price Cap* case of the latest UK government publication on the topic.[11] In the same document, *Low* and *High Price Cap* options are also considered with buy-out prices of £36/tCO_2 and £90/tCO_2 respectively. The relative costs of development-level emission mitigation strategies versus paying into a fund to offset emissions will depend on both the costs of the on-site technologies in question and the buy-out price. The calculation below illustrates why, based on the current assumptions, the AS-based strategies lead to a lower overall cost than the largely PV-led strategies.

Comparison of cost of carbon saving from PV vs. indicative AS price

PV capital cost (£/kWp)	1,450	Typical total installed cost for a new build system in 2013.
Annual electricity generation (kWh/kWp/yr)	858	Value from SAP (for a well-orientated system).
Emissions saving (kgCO_2/yr)	445	Based on 0.519kgCO_2/kWh for displaced grid electricity (SAP 2009 value)
Emissions saving over 30 years (tCO_2)	13.4	A thirty year lifetime for a PV system is relatively optimistic but acceptable for the purpose of this illustrative calculation.

[11] *Next steps to zero carbon homes - Allowable Solutions, Consultation*, DCLG (August 2013).

Cost of carbon saving (capital £/tCO$_2$)	**108.5**	Calculated from the capex assumption above and emission benefit over the period.
Allowable solutions price (capital £/tCO$_2$)	**60**	Central case value from the August 2013 consultation on allowable solutions.

In addition to dwelling-scale energy strategies, community heating-based approaches have also been considered at the higher Code levels. Figure 8 shows the extra over costs of a selection of community heating energy strategies (i.e. those involving centralised heating plant and district heating).

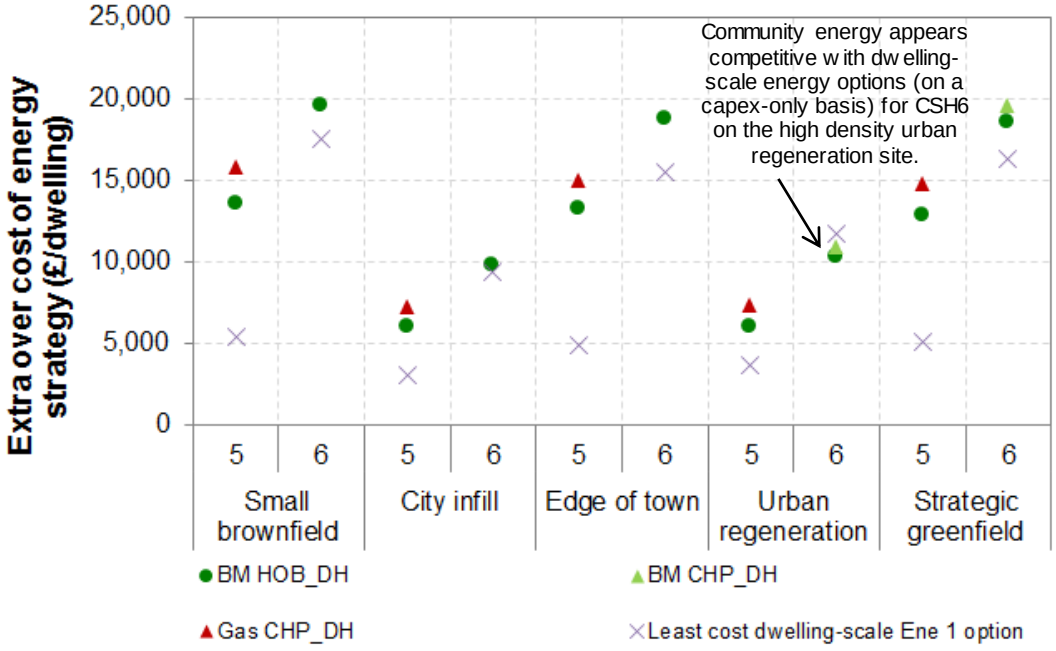


Figure 8: Extra over cost of community energy strategies by site type (and minimum cost dwelling-scale approach), relative to Part L 2010 – average across all dwellings in each development scenario

These results suggest that community energy strategies are only cost-effective at Code level 6, and only for high density sites (e.g. Urban regeneration). Even then the benefit appears marginal and decreasing costs of PV will tend to favour dwelling-scale approaches with high reliance on RES-E generation.

Having said this, the results above are based on community heating for residential-only schemes (consistent with the development types defined). The economics of district heating are highly site-specific and typical schemes also involve non-residential sources of heat demand (as anchor heat loads and to provide increased diversity of demand). Furthermore, this study makes the simplifying assumption that the full costs of energy strategies would be borne by developers. In practice, community energy schemes tend to involve a third party (e.g. an energy services company), that may be able to contribute to some of the capital costs of initiating projects, with a view to recouping the investment over an extended period.

Other strategic drivers for district heating (such as seeding low carbon heat networks that could be used for wider decarbonisation, beyond the new development) suggest there is a case for considering the appropriateness of community heating on a development-by-development basis.

Cost changes over time

This study's results focus on the costs of building to the Code that are in addition to base build costs, where the base building complies with Building Regulations. Given that Building Regulations (in particular Part L) change over time, the extra over costs of building Code homes in future may fall further.

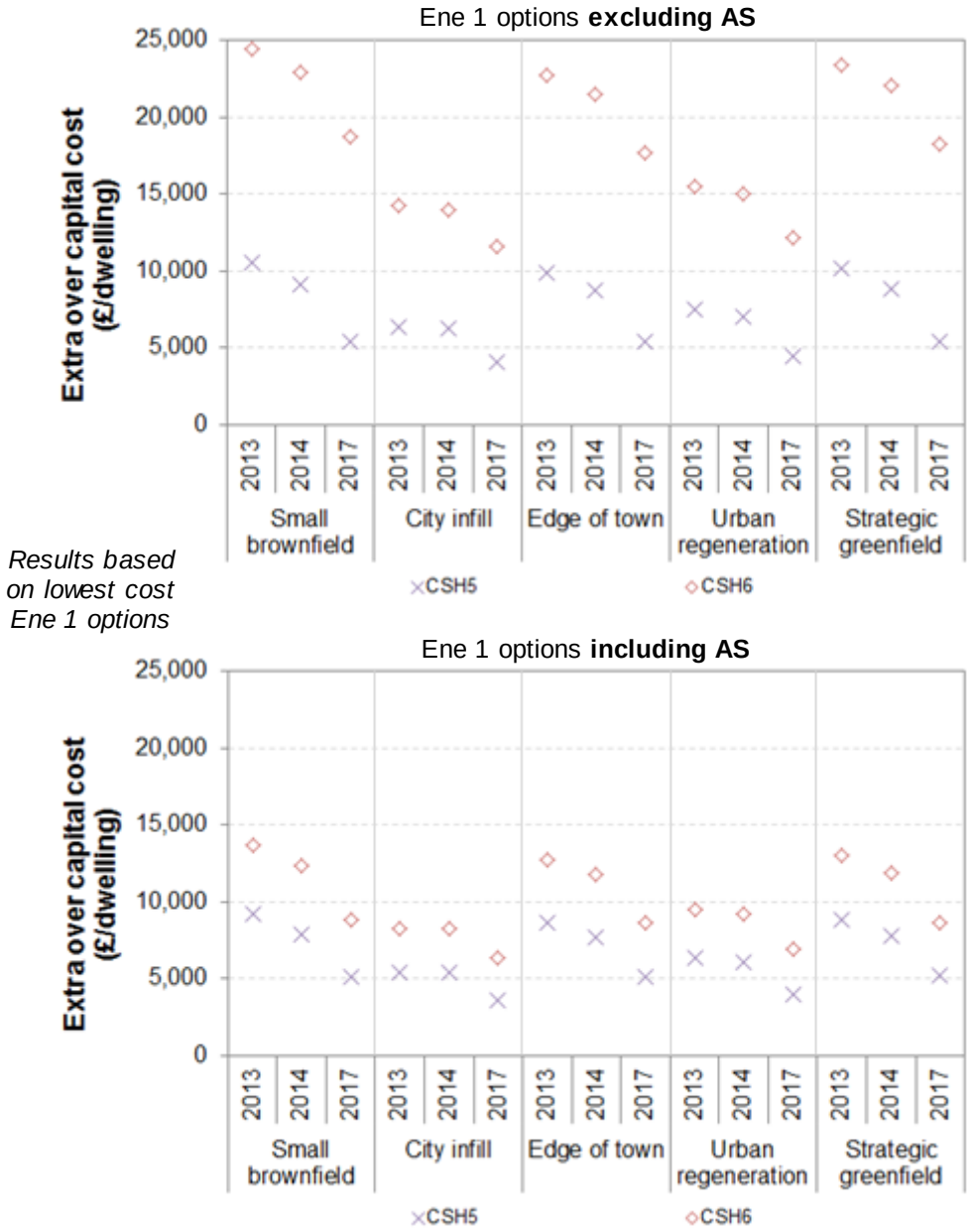


Figure 9: Change in total (average) extra over cost of building to levels 5 and 6 over time

Cost reductions are due to a combination of further falls in the cost of PV, and changes to Part L which will make a building-compliant dwelling more costly to build (i.e. increases to baseline costs in 2014 and 2017 following the introduction of Part L 2013 and Part L 2016 respectively). The greater fall from 2014 to 2017 (compared to 2013 to 2014) is due to the (more stringent) zero carbon homes regulation coming into effect from 2016.