Passivhaus Capital Cost Research Project

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Acknowledgements

This paper was written by Jane Barnes, with input from the Passivhaus Trust 'Costs' technical working group. Members of the working group include: Roger Burton, Chris Parsons, Brian Carroll, Jon Bootland, Kym Mead and Nick Devlin

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Foreword

Passivhaus is currently the leading international low energy design standard with over 37,000 buildings designed and tested to the standard worldwide[1]. The standard is growing in popularity in the UK with more than 250 certified Passivhaus buildings designed and constructed to the standard at the end of 2014 and over 1000 buildings underway, both residential and non-domestic.

Despite these impressive figures, it is still difficult to get a clear picture of the costs associated with Passivhaus building, particularly the extra over costs compared to standard building practices. In Germany, extra over costs are considered to be between 3 and 8%[2]. In the UK figures quoted for costs may be calculated differently in each case, and include different elements, meaning that it is difficult to make useful comparisons, and claims therefore range from 0% to 30% above standard building regulations.

To obtain a clearer picture of Passivhaus costs in the UK, AECOM, in conjunction with the Passivhaus Trust, has therefore undertaken a research study into the capital cost of building to certified Passivhaus standards across a number of affordable housing projects in the UK, using a standardised cost tool to compare projects on a like for like basis[3]. In addition to answering the 'what does it cost?' question, we also investigated the extra over costs associated with building Passivhaus certified homes compared to other UK building standards, including Code for Sustainable Homes (CFSH) Level 4.

There are some difficulties in this comparison, as Passivhaus energy and comfort performance exceeds that of CSH level 4, so the comparison is not like-for-like. Furthermore, the Passivhaus standard has been proven to address 'The Performance gap'[4] - the difference between design and as-built energy performance - which in recent years has caused increasing concern among the construction industry and local and central government[5]. In addition, the CFSH is a broader building standard, which address wider sustainability issues such as water, material and ecology as well.

There are also numerous variables that affect the study results, such as programme length, size of project and timing in relation to the recession, plus other influences such as procurement route, dwelling orientation and availability of services which will have an impact on overall building cost and specification. These factors should be considered carefully in relation to Passivhaus developments.

The results of this study show that for the project type analysed, an average capital cost of £1,800/m² - £1,850/m² of GIFA is achieved, normalised to Q4 2014. This represents a 15-20% uplift comparable to the CFSH 4 standard which is widely used across the UK. The capital cost data has been influenced by significant changes in market conditions over the time period of the study and as such the requirement to continue to monitor Passivhaus project cost data is essential.

In addition, there is a requirement to consider the inherent benefits of Passivhaus development, as there is a potential to offset the capital cost uplifts, particularly in terms of lower running costs and improved occupant comfort throughout the year, which have a significant effect on whole life cost comparisons[6]. The Passivhaus Trust is planning further research on both these topics during 2015.

It is widely accepted that the proposed change in UK building regulations in 2016 will raise the cost of building standard homes, whilst the cost of Passivhaus buildings should decrease with wider.

[1] Passivhaus Trust, January 2015
[2] iPHA, 2013
[3] Passivhaus Cost Template
[4] CEPHEUS results – Jürgen Schnieders & Andreas Hermelink, January 2006
[5] Closing the gap between design & as-built performance – Zero Carbon Hub, July 2014
[6] Whole-life costs of a Passivhaus – Encraft, February 2014

1.0 Introduction

Across the UK construction sector, it is generally accepted that building to certified Passivhaus standards costs more than building to UK Building Regulations standards and / or up to Code for Sustainable Homes Standard Level 4. What is less certain is what those costs are and what the cost uplift is. Costs per square meter of GIFA and percentage uplifts are frequently quoted however it is often unclear what is included and excluded from these rates and from what basis these rates are generated. Adding to this, there is currently limited cost data available and that which does exist is often based on analysis of 'stand-alone' projects; the need for further research into the costs associated with building to certified Passivhaus standards in the UK is clear.

To provide some insight into this, AECOM has obtained cost data from a number of UK projects which meet certified Passivhaus standards. All of the projects sit within the affordable housing sector and are of a similar size and nature to allow benchmark comparisons to be made. The aim of this research was to answer the following key questions:

- *What are the average costs?*
- *Are there any key trends in the cost information that influence outturn costs?*
- *How do the average costs compare to other UK Building Standards?*

This paper summarises the findings of our research, based on the analysis of 11 UK projects, ranging in size from two to twenty units. The next section provides further details on the projects.

1.1 Key Project Information

As part of the research process, we obtained key project information; this was essential to ensure that the analysis of data considered the wider project context. The projects analysed as part of the research project are summarised below. All of the projects are all UK affordable housing developments comprising a mixture of 1, 2 and 3 bed dwellings. The majority of the projects are completed although some are tendered / currently under construction.

Project	**Nr of Units**	**Construction Method**	**Procurement Route**	**Base Date**	**Standards Achieved**	**Cost/m2 GIFA (£)* Base date / Q4 2014**
A	0	Timber frame	Negotiated design and build	2011	Passivhaus CFSH 4	1,400 / 1,561
B	4	Cavity wall brickwork	Negotiated design and build	2011	Passivhaus CFSH 4	1,442 / 1,608
C	14	Thin joint blockwork and external insulation/render	Single stage design and build	2010	Passivhaus CFSH 4	1,561 / 1,728
D		Timber frame	Negotiated design and build	2012	Passivhaus CFSH 3	1,644 / 1,808

E	14	Thin joint blockwork and external insulation/render	Single stage design and build	2013	Passivhaus CFSH 4	1,672 / 1,757
F	5	Timber frame	Single stage design and build	2013	Passivhaus CFSH 4	1,704 / 1,789
G		Cavity wall brickwork	Single stage design and build	2013	Passivhaus CFSH 4	1,780 / 1,869
H		Timber frame	Single stage design and build	2014	Passivhaus CFSH	1,857 / 1,876
I		Thin joint blockwork and external insulation/render	Single stage design and build	2013	Passivhaus CFSH 4	1,978 / 2,076
J		Thin joint blockwork and external insulation/render	Negotiated design and build	2014	Passivhaus CFSH 3	1,997 / 1,997
K	1	Thin joint blockwork and external insulation/render	Negotiated design and build	2014	Passivhaus CFSH 4	1,983 / 1,983

*Excludes site abnormals and elements of achieving CFSH levels

The cost per m² of GIFA is identified above. This has been calculated for each scheme based on its ‘base date’ (date at the time of tendering the scheme). An uplifted rate has also been provided based on tender price inflation to 4th Quarter 2014, using the BCIS Tender Price Indices. Again, this is to give a ‘like for like’ comparison between schemes.

2.0 Methodology

2.1 Cost Template

Cost data was obtained using a standardised template developed by AECOM to mitigate the potential for ambiguity between cost elements to occur and to ensure that all project costs were captured. The reason for this was to improve accuracy of data returned and to allow comparisons between projects to be made on a like for like basis.

The template comprised four sections as follows:

Section 1: Preliminary Information

Project information was obtained to inform the context and assist with later analysis of figures provided. This included project details, construction method, air-tightness strategy and certification strategy (i.e. block by block or individual units).

Section 2: Cost Template

Key construction elements were listed with costs and quantities to be allocated against each. All site abnormalities (e.g. ground remediation, archaeology etc.) and associated costs were also identified within this section, allowing these to be omitted from analysis later to give benchmark costs. Key aspects of Passivhaus construction such as external walls, MVHR system and air-testing costs were separated out.

Section 3: Evaluation Questions

Respondents were asked to complete three questions, again to assist with later analysis. These focused on: (1) Any elements of the project that were difficult to price/ why, (2) Not taking account of TPI, would they complete the project again for the same price and (3) What would they do differently next time.

Section 4: Guidance Notes

This section provided guidance on how to complete each of the above sections, with the aim of reducing the potential for inaccuracies to occur in the data returned.

The cost template was initially piloted on three of the projects, updated to incorporate relevant suggested amendments and issued to a further eleven participants. Out of the 14 issued, 11 were returned. To improve comparability between projects, the cost data was standardised by omitting abnormal costs from the figures provided and applying tender price inflation to historic data.

2.2 Limitations

There were a number of limitations associated with the data provided, as outlined below.

- All costs reported are exclusive of costs typically incurred by the client prior to tender. This includes pre contract design and survey fees and land acquisition costs.
- Although the cost template was developed to mitigate ambiguity, there is still a reliance on third parties to complete costs accurately.
- Not all elements of the cost template were completed in full by the participants. When queried, this was due to the design and build procurement route resulting in limited breakdowns of costs and quantities, particularly on the more historic projects where the contractor was no longer involved. As such, some assumptions were made in relation to cost allocations between construction elements.
- The projects analysed were at varying stages of construction with some being tendered costs only. These schemes may go on to incur extra costs as the project moves forward to construction.
- The number of projects analysed is limited as a result of responses obtained and the pool of projects available in the UK for analysis.

3.0 Data & Analysis

3.1 Overview of Average Costs

The average costs were analysed on a cost per m2 of GIFA and cost per dwelling basis. Because all of the projects comprised a mixture of dwelling sizes, the average dwelling costs per scheme are comparable. These costs include all external works and post-contract fees (i.e. the entire post-contract build-cost). TPI adjustments were made to all rates to give comparable data. The TPI adjusted costs per dwelling for the external walls, external windows and doors and mechanical and electrical components were also analysed as it was considered that these construction elements had the greatest potential to impact overall costs on Passivhaus projects. Projects B and I did not return cost data in sufficient detail so were excluded from the key component analysis.

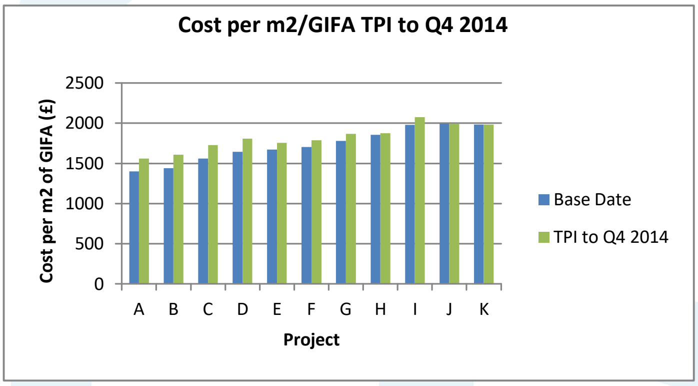

Figure 1: Cost per m2 of GIFA
The costs range from £1,400/m² (Project A) to £1,997/m² (Project J). The average cost of all of the schemes analysed based on ‘base dates’ is £1,729/m². Uplifted to Q4 2014 tender prices the average cost is £1,823/m². There is a significant increase in costs for schemes tendered or completed from 2012 onwards, as would be expected as a result of the 2008-2010 economic downturn.

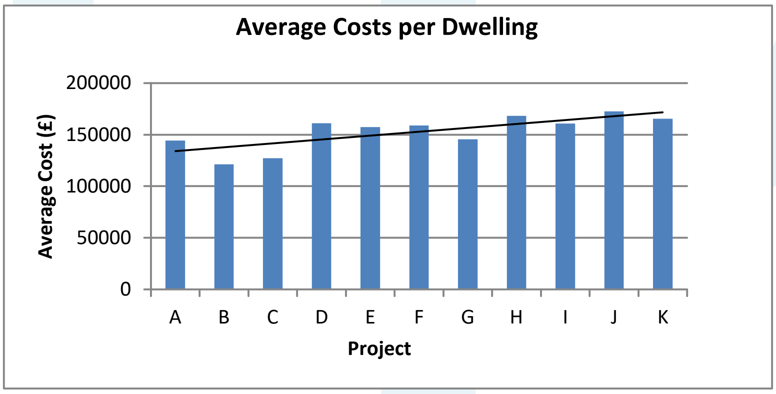

Figure 2: Costs per Dwelling
The cost per dwelling ranges from £108,304 (Project B) to £172,644 (Project J). The average cost per dwelling across all of the schemes is £145,054. Schemes B, C and G returned the lowest costs; both schemes were primarily long terraces of units which were air tested and Passivhaus-certified on a block basis, which is likely to have contributed to cost effectiveness.

3.2 Key Trends

Timing of Projects

The primary difference in costs between projects is attributed to the point in time at which they were tendered / constructed. Those schemes which were tendered and completed prior to 2012 (tendered during the economic downturn) achieved a significantly lower cost than those completed and tendered from 2012 onwards, with significant uplifts for recent (2014) schemes. Even when rates are TPI adjusted, the pre-2012 schemes retain significantly lower costs. During this period commercial ‘adjustments’ in order to secure work were commonplace. For all of these projects, the respondents confirmed that they would not be able to deliver these projects for the same rates again (regardless of TPI), indicating that a loss may have been made.

Projects tendered / on-site from 2014 onwards saw a significant uplift in cost which is likely to be attributed to the rising market; whilst Passivhaus component materials such as triple glazed windows are more readily available than they were during the downturn years, the rising materials and labour market is likely to counteract any savings that would have been realised otherwise.

Procurement Structure

All of the projects analysed were procured via a design and build route. Respondents were asked the level of design detail available at the time of tendering the project in order to determine whether this influenced the costs returned. For those projects where planning stage design was used (current RIBA stage 3), the costs were on average 5% higher than those schemes where the design was further developed prior to tender (current RIBA stage 4 onwards).

Air-tightness Strategy

Those projects for which air-tightness was measured on a block basis of 3 dwellings or more returned lower overall dwelling costs than those with individual and / or semi-detached dwellings. Terraced dwellings generally generate a lower outturn cost which may be further enhanced by reduced insulation requirements resulting in a larger impact on the cost of Passivhaus construction than other standards.

Orientation

Dwellings with a predominantly North-South orientation generated lower overall costs for windows and doors compared to those with other orientations. This may be as a result of the optimum solar gain situation being achieved on North-South configurations, reducing the number of windows required; although it could be argued that any savings may be off-set by the requirement for additional solar shading in some circumstances.

Availability of Services

Those projects where gas was available and used as part of the heating and hot water strategy generated significantly lower M&E costs as opposed to projects where gas was unavailable, with an average reduction of approximately 20%. This may be as a result of contractor risk pricing due to the requirement for potentially more ‘complex’ M&E strategies.

3.3 Comparison to other UK Building Standards

Overall within the Sector

The average cost per m2 for the projects analysed was then compared to 50 similarly sized projects completed by AECOM within the UK affordable housing sector in the last three years, to varying standards but primarily Building Regulations / CFSH 3 / CFSH 4.

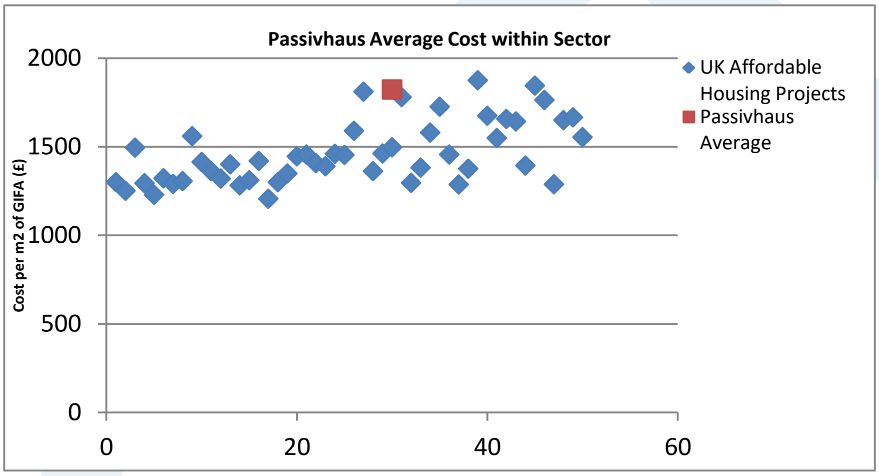

Figure 3: Sector Comparison

The average cost is at the high end of other benchmark costs however some CFSH 4 schemes attracted a similar cost and some exceeded the average for Passivhaus. The average sector cost equates to £1,465/m2 GIFA. Based on the projects analysed, the uplift to Passivhaus ranges from 10% on earlier schemes to 23% on more recently tendered projects.

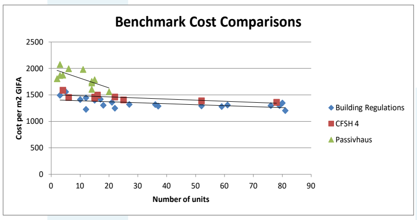

Figure 4: Benchmark Cost Comparisons

The 11 Passivhaus projects analysed are shown in conjunction with a number of CFSH 4 and UK Building Regulations standard projects. The average additional cost per m2 for Passivhaus from CFSH Level 4 equates to £310-£320 or 15-20%. From Building Regulations standards to Passivhaus the average cost uplift is 20-25% or £450-£500/m2. As would be expected, there is a clear correlation between number of units and cost; the higher the number of units, the lower the cost. This is common across all standards.

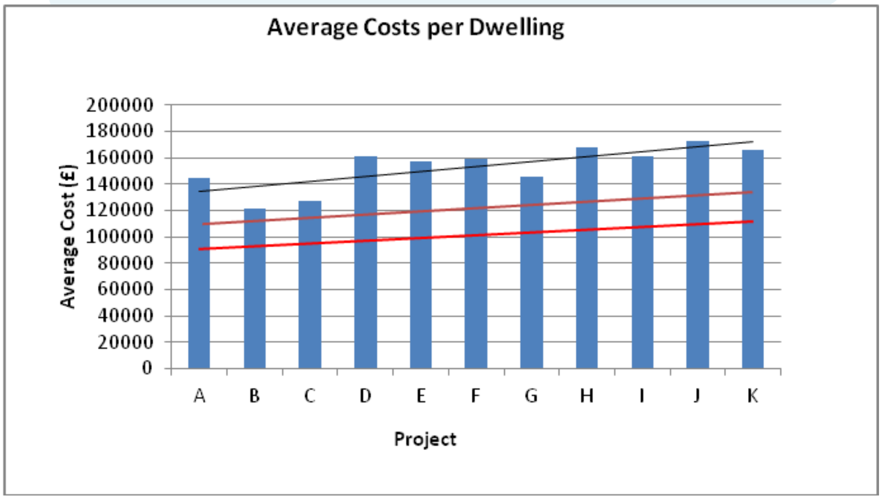

Figure 5: Average Costs per Dwelling Comparison

For Passivhaus the average cost per dwelling ranges from £108,304 (Project B) to £172,644 (Project J). The average cost per dwelling across all of the schemes is £145,054 (black line). Compared to benchmark data for UK Building Regulation standard dwellings, at around £105,000 (red line), the uplift is 20-25%. Compared to benchmark data for Code 4 level dwellings, at around £120,000 (orange line), the cost uplift is 15-20%.

To identify the key areas of cost difference, the average Passivhaus and CFSH 4 elemental costs were analysed on a project by project basis. Percentage uplifts are denoted below and are as expected in terms of external walls, windows and doors, M&E installations and preliminaries attracting the highest uplifts. It was not anticipated that internal walls or finishes would attract any differences cost-wise and this may be due to anomalies in data or contractor's pricing in risk across all items on the basis that projects 'carry the Passivhaus badge'.

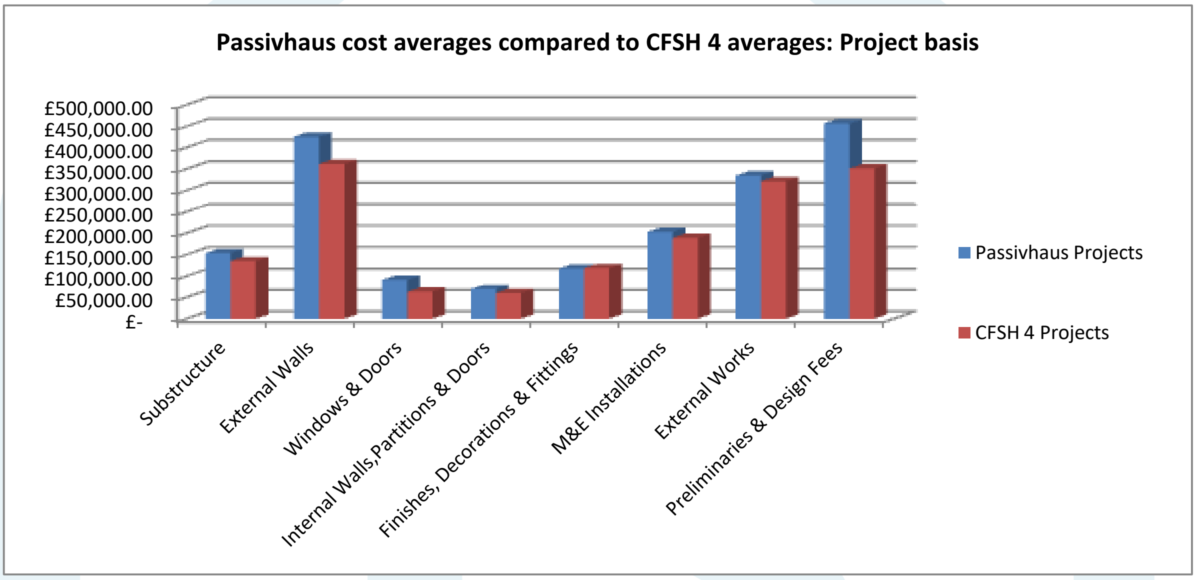

Figure 6: Passivhaus averages compared to CFSH 4 averages: Building Components

- Substructures: 8% uplift
- External walls: 15% uplift
- Windows & Doors: 30% uplift
- Internal walls: 13% uplift
- Finishes: 1% decrease
- M&E installations: 7% uplift
- External works : N/A
- Prelims & Fees: 23% uplift

M&E installation uplift costs are lower than was identified within the pilot study (where the uplift was 15%), and do not attract a significant uplift over and above costs associated with CFSH 4 installations. Substructure costs also attract an uplift although not significant and attributed by the majority of respondents to increased insulation levels. The uplift in preliminaries and fees is attributed by respondents to additional design fees, additional air-testing and Passivhaus certification (for fees), and greater attendance on site for preliminaries. One respondent advised that their site manager costs doubled for the project due to time spent ensuring detailing was completed to the required standard and another had appointed additional staff to manage this process. The key uplifted build components are explored further below.

4.0 Conclusions & Recommendations

All 11 respondents returned cost data that could be used to analyse the costs associated with constructing to certified Passivhaus standards on UK affordable housing projects. By implementing a standardised cost template, the cost data was able to be compared on a like-for-like basis, removing the ambiguity that is often present in figures quoted within the UK construction sector.

The results give an indication of the cost per square metre for building to certified Passivhaus standards on smaller scale, mixed dwelling type affordable housing projects; typically around £1,800/m² - £1,850/m² of GIFA. It is however clear that external market factors have significantly influenced the cost data, and that the rising market currently being experienced may be counteracting any savings from increased supply that may have been realised since the earlier projects were undertaken.

Other influences such as procurement route, dwelling orientation and availability of services are likely to have an impact on overall costs and should be considered carefully in relation to Passivhaus development.

In comparison to other UK sustainability standards, Passivhaus does attract an uplift currently, with an increase in costs of 15-20% over and above CFSH 4. The primary contributors to this are increased costs for external walls, windows and doors and contractor preliminaries. Substructure and M&E installations cost uplifts were lower than anticipated, with a number of Passivhaus projects achieving lower costs for M&E installations than CFSH 4 averages. There was a clear trend towards lower M&E installations costs where gas was readily available on site and utilised as part of the heating and hot water strategy.

A clear link between level of design at the time of pricing was also identified, with more detailed design information generating more cost effective prices. This is likely to be due to a reduction in risk pricing as design is further defined.

It would be highly beneficial to continue to track Passivhaus project costs as the market continues to change, in order to increase the amount of data analysed and draw further conclusions, particularly in relation to factors such as construction method.

It would also be useful to determine whether a performance gap exists within the tools used to measure compliance with other sustainability standards and end product. PHPP is comprehensive in terms of ensuring that specified standards are met (and evidence provided) meaning that there is no room for reductions in specification. Other tools may not offer this level of certainty in terms of the end standard that is actually achieved and this may account for a proportion of the cost uplifts between standards such as CFSH and Passivhaus.

Lastly, the inherent ‘value’ of Passivhaus certified buildings is not considered within this research. Evidence of significantly reduced fuel bills, reduced rent arrears, reduced maintenance costs, increased property values and health benefits is beginning to emerge within the sector and whilst the data obtained for this study indicates a premium for constructing to the Passivhaus standard, this may be far outweighed by the potential benefits.