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A brief review of the development of *Passivhaus* in the UK social housing sector

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Abstract

The social housing sector is lacking in both quantity and quality of new build and existing homes. The existing design and development of social housing are also in urgent need of review in terms of energy efficiency as the cost of living crisis deepens. The *Passivhaus* standard provides a potential solution for both new build and existing homes, offering a design strategy that benefits the health and well-being of end-users, reduces fuel poverty, and minimises GHG emissions. However, the challenges and possibilities regarding the *Passivhaus* standard and social housing are not well understood. This paper reviews previous research and practice of *Passivhaus* projects in the UK and explores *Passivhaus* methodology from the perspectives of social housing providers, the design and construction team, and the end-users behaviour and experience. By doing so, it identifies the barriers and opportunities when implementing the *Passivhaus* methodology in the UK social housing sector.

1. Introduction

The *Passivhaus* standard is a green building methodology established in Germany in the 1990s. It distinguishes itself from other green building standards for its sole focus on energy efficiency. Studies have suggested that the *Passivhaus* standard is a credible way to achieve considerable energy reduction (50%-83%) in both new build and retrofitted buildings [1,2,3], whilst providing a healthy and comfortable indoor environment [4].

The rigorous energy efficiency criteria the *Passivhaus* standard provides are especially beneficial when applied in the social housing sector where a larger proportion of households living in fuel poverty than the UK average. The first social housing *Passivhaus* in the UK was completed in 2010 in Scotland. Since then, over 50 city and district councils and housing associations nationwide have delivered social housing *Passivhaus* projects. A total of 73 social housing *Passivhaus* projects are recorded online in the *Passivhaus* Trust database [5]. The trend will continue with a growing number of councils and local authorities requiring new homes to be built to the *Passivhaus* standard. Recently Renfrewshire Council has committed to upgrading 3500 social housing units to EnerPHit standard. Dublin City Council has voted to make *Passivhaus* standards mandatory for all new buildings. In 2019 the Goldsmith street *Passivhaus* social housing project, developed by Norwich City Council, has become the first social housing project, and the first *Passivhaus* project to win the RIBA Stirling Prize. However, amongst 1,600 social housing providers

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in the UK, only 3% have delivered *Passivhaus* projects. The development is hindered by difficulties such as initial capital investment [6], unfamiliarity and risks involved in procurement [7] and insufficient training for supply chain [8], as well as user experience of overheating [9], the use of control systems [10] and restricted user behaviour [11].

2. Challenges and barriers from the delivery team

Passivhaus is a relatively new building approach in the UK and the main challenges for the delivery team are the additional cost associated with Passivhaus construction; the different technical approach needed for design and construction; and the lack of skills and expertise held by architects and contractors.

From the perspective of the delivery team, the uplifted cost is the first and foremost barrier to carrying out a *Passivhaus* project. The additional cost on average was regarded by Barnes [8] to be 15-25% of the project cost. The main reason for the uplifted cost is in securing the external envelope, increased insulation and airtightness requirements. Glazing area, especially, has been considered a key driver of construction cost [7]. It represents the highest cost per meter square of all variable components. Minimising the glazing area whilst ensuring sufficient solar gain and natural light is crucial in decreasing the cost. Similarly, other design factors such as dwelling type and orientation are also closely related to how energy balance is calculated and if the extra cost is incurred. It has also been concluded that projects with available gas supply onsite cost less on average for M&E installation than those without, due to a less complex M&E installation. Furthermore, research suggested that the level of design at the time of pricing was also linked [8]. Tendering using planning stage design details returned a 5% higher cost on average than those that used a further developed design detail.

The additional costs of building to this standard have been reducing. *Passivhaus* Trust has recently published a cost analysis of *Passivhaus* projects, claiming a reduction in construction cost as the methodology has matured [12]. The report has shown an 8% extra cost, with a further 4% reduction when adopted at scale. Studies have also advised on strategies in which a higher cost-efficiency can be achieved, such as simplifying the building layout and implementing a hybrid ventilation system [13], or using the alternative heating load criteria instead of the heating demand criteria when calculating energy use [7]. Such strategies are key considerations when scaling up social housing *Passivhaus* projects.

Any additional costs to deliver projects needs to be balanced with the substantial benefit of reduced operating costs. This is particularly relevant to the social housing sector where rent arrears are often associated with high energy costs for tenants [19]. In addition, the overall increase in quality of construction associated with *Passivhaus* is associated with lower maintenance costs for the housing association [20].

Other areas of challenge include the procurement process and supply chain. This is due to the relative innovation of technology associated with a *Passivhaus* project. Specifically, the contractor and consultant's unfamiliarity with the design and construction of *Passivhaus* creates an uncertain risk premium and uncertain tender market. This also applies to quantity surveyors, where such unfamiliarity could lead to inaccuracy in making the cost plan and project management. There is a lack of design guidelines to ensure the achievement of the *Passivhaus* certificate. Designing a *Passivhaus* often requires certified *Passivhaus* designers and experienced contractors. Unfamiliar with the construction of *Passivhaus* projects could have time and cost implications. The existing *Passivhaus* expertise is also unevenly spread across the country, making skills-building, and experience sharing amongst the supply chain difficult.

3. End-users perception of *Passivhaus*

Passivhaus as a form of ultra-low energy home introduces a paradigm shift for domestic control of heat (and cooling) in our homes. Control of the energy balance is integral to achieving good energy performance. This is achieved through a carefully balanced flow of heat and fresh air through the Mechanical Ventilation and Heat Recovery system (MVHR), coupled with some form of heating, and increasingly cooling to maintain a good level of comfort in the building. The MVHR system, integral to *Passivhaus*, replaces wet central heating systems, often heated by gas boilers. The controls common in this system include an MVHR control panel, timers and programmable controls. *Passivhaus* control systems are fundamentally different and can incorporate a range of devices such as an additional Domestic Hot Water system (DHW), a backup heating system, and a renewables generation system, with their own individual set of controls. In the last few years, these 'traditional' controls have been replaced or supplemented with smart thermostats that learn the housing occupants' behaviours and adjust heating systems to the most efficient delivery of heat.

In addition to the control systems, a *Passivhaus* requires an understanding of the close relationship the building has with external conditions. The reliance on solar gain in the *Passivhaus* energy balance means that occupants need to adapt when there is less or more solar radiation than predicted. For instance, research has found that some issues reported in Post Occupancy Evaluation studies, such as overheating [14] and Indoor Air Quality (IAQ) [15] are linked with the users' control behaviour.

Lack of familiarity and awareness of systems to heat, cool and control the spaces may contribute to a performance gap in *Passivhaus* [16]. The array of solutions in new build homes, and retrofit of existing buildings create a largely uncharted socio-technical landscape for occupants to navigate comfort [17]. Moreover, depending on the user's age, gender, cultural background, physical and mental abilities, as well as their opinions, attitudes and beliefs, the idea of a 'controlled environment' or 'smart homes' represent very different practices in their day-to-day energy management.

Research [11] into the lived experience of PH demonstrates that adaptation is needed to achieve comfort. This takes place over an extended period, where both 'comfort-driven' and 'energy efficiency-driven' behavioural adaptations are recorded in *Passivhaus* occupants. Their research comparing two affordable and social housing *Passivhaus* projects [18] stressed the importance of support and energy monitoring in the post-occupancy stage for social tenants, suggesting that the end-users are an integral part of the *Passivhaus* system that need to be guided and supported to fully benefit from from the *Passivhaus* model. It also showed potential for the scaling up of the *Passivhaus* project to benefit from community-oriented energy auditing and training to support sustainable behaviour change.

Fuel poverty is substantially higher in social housing than the average across UK households. Tenants of *Passivhaus* homes experience significantly lower fuel bills and improved comfort. There is also evidence that health conditions are improved as a result of the increased air quality and thermal consistency experienced. If these benefits to occupants are to be realised, further research and evaluation of the lived experience are required to measure the societal impact of moving a broad implementation of this approach to housing.

4. Conclusion

Key issues emerging from this review are well established in the literature. Delivery mechanisms and the cultural and practice norms have the potential to ease the barriers to creating more homes to the improved energy performance needed to reach a zero-carbon society. The social housing sector has a tradition of innovation and often delivers pilot projects to improve sustainability and quality. Interest in the *Passivhaus* model is evident with social housing providers, local councils and cities, recognising the approach leads to predictable performance and large reductions in energy costs. The challenge seems to exist for the scale of the task at hand. Investment linked to actual performance of housing needs to be adopted to shift the approach from building to standard to creation of homes that offer affordable comfort.

The design and construction professionals continue to be challenged by cost, procurement and supply chain issues that need a systematic approach to carry out this low-energy housing solution effectively in social sectors. Shifting positions from professional bodies in response to the climate emergency is driving interest in *Passivhaus* due to its ability to deliver high-quality low energy homes. Skills and expertise need to develop throughout the supply chain to ensure that knowledge and experience are shared for the benefit of future projects. In addition, not enough evidence exists on the lived experience of *Passivhaus*. Successful projects are celebrated and serve to encourage further uptake of the approach. However, there is a need to research the realities of living in these homes. Research is needed to address the paradigm shift in the home, the inevitable digitalisation and automation of the built environment and its effect on user interaction, satisfaction and sustainable behaviour in passively designed buildings. Furthermore, research is urgently needed to address overheating issues both from a design/delivery perspective and from a user behaviour perspective, where overheating is a more frequent problem with increasing extremes of summer temperature.

Reference

1. Saldaña-Márquez, H., Gómez-Soberón, J.M., Arredondo-Rea, S.P., Almaral-Sánchez, J.L., Gómez-Soberón, M.C., Rosell-Balada, G., (2015) The *Passivhaus* standard in the mediterranean climate: evaluation, comparison and profitability, J Green Build, 10 (2015), pp. 55-72, 10.3992/jgb.10.4.55

2. Moran, F., Blight, T., Natarajan, S., A. Shea, A., (2014), The use of Passive House Planning Package to reduce energy use and CO2 emissions in historic dwellings, Energy Build, 75 (2014), pp. 216-227, 10.1016/j.enbuild.2013.12.043

3. Echarri-Iribarren V., Sotos-Solano, C., Espinosa-Fern, a., Prado-Govea, R., (2019) The *Passivhaus* Standard in the Spanish Mediterranean: Evaluation of a House's Thermal Behaviour of Enclosures and Airtightness, Sustainability, 11(13), p. 3732. DOI: 10.3390/su11133732.

4. Mlecnik, E., Schütze, T., Jansen, S. J. T., de Vries, G., Visscher, H. J. & van Hal, A. (2012) End-user experiences in nearly zero-energy houses. Energy and Buildings, 49, 471-478.

5. Zhao, J., (2022), Implementing *Passivhaus* Standard as A Social Housing Model in the UK – Barriers and Opportunities, *Implementing the UN Sustainable Development Goals - Regional Perspectives, Volume 4 the European Region*, edited by Walter Leal Filho, Springer, under review.

6. Lynch H. (2014), *Passivhaus* in the UK: the challenges of an emerging market. UCL; 2014. https://discovery.ucl.ac.uk/id/eprint/1418470 [accessed 06/06/2022].

7. Forde, J., Hopfe, C. J., McLeod, R. S., Evins, R., (2020), Temporal optimization for affordable and resilient *Passivhaus* dwellings in the social housing sector, *Applied Energy*, Volume 261, 2020, 114383, ISSN 0306-2619, https://doi.org/10.1016/j.apenergy.2019.114383.

8. Barnes J. (2015), *Passivhaus* capital cost research project, *Passivhaus* Trust, AECOM, retrieved from: https://www.*Passivhaus*trust.org.uk/UserFiles/File/Technical%20Papers/150128%20PH%20Capital%20Costs.pdf [accessed 06/06/2022]

9. Sameni, S. M. T., Gaterell, M., Montazami, A. & Ahmed, A. (2015) Overheating investigation in UK social housing flats built to the *Passivhaus* standard. Building and Environment, 92, 222-235.

10. Stevenson, F., Carmona-Andreu, I. & Hancock, M. (2013) The usability of control interfaces in low-carbon housing. Architectural Science Review, 56(1), 70-82.

11. Zhao, J., Carter, K., (2020) Do passive houses need passive people? Evaluating the active occupancy of *Passivhaus* homes in the United Kingdom, *Energy Research & Social Science*, Volume 64,2020,101448, ISSN 2214-6296, https://doi.org/10.1016/j.erss.2020.101448

12. *Passivhaus* Trust (2019) *Passivhaus* Construction Costs, *Passivhaus* Trust, retrieved from: https://www.*Passivhaus*trust.org.uk/UserFiles/File/research%20papers/Costs/2019.10_*Passivhaus*%20Construction%20Costs.pdf, [accessed 06/06/2022]

13. Costanzo, V., Fabbri, K., Piraccinib, S., (2018), Stressing the passive behaviour of a *Passivhaus*: An evidence-based scenario analysis for a Mediterranean case study, *Building and Environment,* Volume 142, 2018, Pages 265-277, ISSN 0360-1323, https://doi.org/10.1016/j.buildenv.2018.06.035.

14. Fletcher, M. J., Johnston, D. K., Glew, D. W., Parker, J. M., (2017) An empirical evaluation of temporal overheating in an assisted living *Passivhaus* dwelling in the UK, *Building and Environment*, 121, pp. 106–118. DOI: 10.1016/j.buildenv.2017.05.024.

15. Moreno-Rangel, A, Musau, F, Sharpe, T & McGill, G (2021), Indoor Air Quality Assessment of Latin America's First *Passivhaus* Home, *Atmosphere*, vol. 12, no. 11, p. 1477, <https://search.ebscohost.com/login.aspx?direct=true&db=edswsc&AN=000725998500001&site=eds-live&scope=site>.

16. Gupta, R. (2019) Meta-study of the energy performance gap in UK low energy housing, Meta-study of the energy performance gap in UK low energy housing. Available at: https://search.ebscohost.com/login.aspx?direct=true&db=edsoai&AN=edsoai.on1128271529&site=eds-live&scope=site (Accessed: 12 May 2022).

17. Ellsworth-Krebs K, Reid L and Hunter C (2019) 'Integrated framework of home comfort: relaxation, companionship and control' Building Research & Information, (2019), 202-218, 47(2)

18. Zhao J., and Carter K., (2016), Barriers and opportunities in the design and delivery of social housing *Passivhaus* for adaptive comfort' Windsor Conference 2016, Available at: https://search.ebscohost.com/login.aspx?direct=true&db=edsoai&AN=edsoai.on1080366428&site=eds-live&scope=site.

19. Colclough S., Kinnane O., Hewitt N., & Griffiths P. (2018) Investigation of nZEB social housing built to the Passive House standard, Energy and Buildings, Volume 179

20. Alencastro J., Fuertes A., Fox A. & de Wilde P. (2019) The impact of defects on energy performance of buildings: Quality management in social housing developments, Energy Procedia, Volume 158, Pages 4357-4362