Housing Performance Evaluation

Understanding the evidence base and the case for change

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Background

In 2019 Homes accounted for 20% of all UK CO2 emissions in terms of their energy use[i]. All new homes in England are required to be net zero carbon by 2050 under the Climate Change Act[ii]. However, new homes in the UK currently emit two to three times *more* carbon dioxide than predicted[iii]. The UK Zero Carbon Hub[iv] identified a wide housing performance gap between design intentions and the final construction of new housing. This included: lack of integrated design between fabric, services and renewable energy systems, poor installation of fabric and services, lack of site team skills and energy performance verification. A further review of existing homes, 'Each Home Counts'[v] set out the need for better installation standards.

The Final Hackitt Report 'Building a Safer Future[vi]', following the deadly Grenfell Tower disaster in 2017, highlighted a wider national cultural failure in the building sector which has created a 'race to the bottom' caused either through ignorance, indifference, or because the system does not facilitate good practice. There is insufficient focus on delivering the best quality building possible, in order to ensure that residents are safe, and feel safe. Recommendations include:

- developing a clear model of risk ownership with a risk-based approach to the level of regulatory oversight based on outcomes,
- transparency of information and
- an audit trail requiring a greater level of inspection – all of which must recognize buildings as systems to avoid siloed thinking.

These findings are echoed in other MHCLG reports which have highlighted the poor indoor air quality in many new homes due to lack of adequate ventilation[vii] and the significant risk of new homes overheating[viii]. In a recent national survey by the Design Council[ix], only 56% of residents reported that their home gets the basics right and more than half feel that their home life is becoming more complicated and stressful.

Much of the above could be avoided if housing development and retrofit was based on an improvement cycle informed by adequate feedback from systematic BPE.

Overview

- Building performance evaluation (BPE) during the occupancy stage can identify and rectify performance failures, generating cost savings, minimizing risks and reducing carbon emissions.
- Standards, protocols, costs and adequate Professional Indemnity insurance are key considerations
- Clients are unlikely to carry out BPE as 'normal' unless there is regulatory change.
- Professional institutions are increasingly requiring members to provide BPE data from the occupancy stage
- The Building Performance Network is developing a national resource platform for all stakeholders and promoting best practice in BPE undertaken during the occupancy stage.

The business case for BPE

The top 6 reasons for housing clients and design teams to carry out BPE as a routine activity are: process and product improvement, reduced risk and hidden liabilities, reduced defects, reduced maintenance, future proofing and improved customer satisfaction, which all result in a better reputation, repeat business and increased profitability. BPE provides a means to actively manage a project 'risk register'[x] and systematically check design, construction, installation and commissioning quality at key stages to ensure the project meets its intended standards.

Once BPE is routinely embedded as part of an organizational learning process, a virtuous circle is created where lessons from BPE on previous projects carried out by the organization can feed into the development process from the outset, providing continuous quality improvement. Architype Architects have successfully monitored over 40 projects and use BPE feedback as part of their organizational culture[xi]. They now use their BPE results to report their positive performance with evidence that is impressive to clients and gains business. Recognising the added value of this process, Architype Architects have now set up their own performance improvement consultancy based on BPE[xii].

Current Building Regulations and Standards

Carrying out BPE to check the actual performance in use is a voluntary activity which currently sits outside of the UK Building Act[xiii]. The Committee on Climate Change (CCC), an independent advisory body to the UK government, has recommended that all new homes should be performance monitored for CO2 emissions[xiv]. A New Homes Ombudsman has been introduced by the UK government[xv] to raise the quality of housing, in response to the poor performance of housing development. This sits alongside the current Housing Ombudsman[xvi] which is set up by law to look at complaints about registered housing organisations. In addition, a new British Standard PAS2035[xvii] has been developed to shape the process of delivering deep retrofit to 27 million existing homes in the UK by 2050. This standard includes BPE verification and is mandatory for all publicly funded housing grants. A new British Standard 40101 for Building Performance Evaluation is set to be in place by December 2021, to provide policymakers with an additional BPE compliance route.

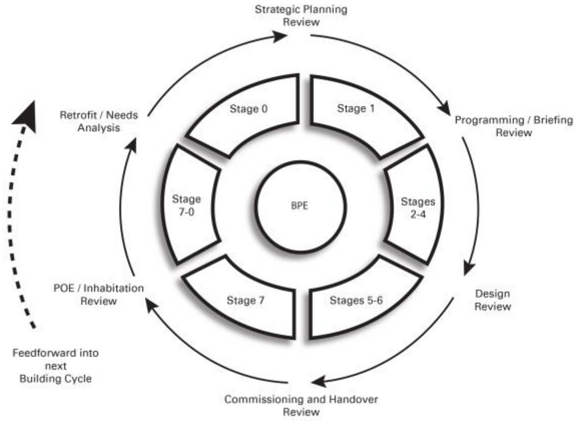
Introducing Building Performance Evaluation

Definitions.

BPE can take place at any or all stages of the housing lifecycle, from inception through to occupancy[xviii] (BSRIA). It can be carried out as a comprehensive exercise to drive quality from the outset to the end point, or as a trouble-shooting exercise to identify specific areas of improvement in existing housing stock, using carefully selected methods that are appropriate to the task in hand[xix]. It should also involve feedback from the occupancy stage to inform the briefing, design modelling, construction and commissioning stages. The occupancy stage is a critical part of BPE that is currently overlooked by regulation, and thus often overlooked by housing developers, apart from customer surveys. Post-occupancy evaluation (POE) refers to BPE studies that are undertaken specifically during building occupancy, and may include quantitative and qualitative information such as energy monitoring, studies of indoor environmental quality, comfort, building design, surveys and interviews with occupants and building walk-throughs[xx].

Process.

BPE is typically considered by housing developers either at the outset of any project or opportunistically during the design or after completion of a project. In the former case, it is built into the project budget during the feasibility stage, and developed in detail during the brief development for the design team. It is then carried out immediately after the completion stage, usually for a period of 9 months to two years. It is usually a newly available external source of funding that triggers BPE opportunistically. BPE can also be offered by architects as part of their service and is included in the RIBA Plan of Work[xxi].



RIBA Plan of Work Stages related to BPE and POE activities.

State of the art methods

BPE is a rapidly evolving area with new evaluation methods and techniques being developed as new research emerges. There is accelerated BPE innovation with large IT companies developing smart monitoring and management systems. The freely available Wood Knowledge Wales comprehensive BPE guide for housing[xxii] identifies 12 current 'core' BPE methods which are seen as an essential first step to understanding the performance of homes once they are occupied: Design and documentation review, Handover review, Early stage overheating analysis (GHA), Energy strategy review, Thermal bridging and moisture review, Site inspections and visits, Airtightness review, checks and tests, Commissioning, Acoustic checks and testing of ventilation system, Energy use audit, Water use audit, and User surveys. The guide describes when and how to use these methods, with a useful 'Toolpack' for clients and the design team. Additional more detailed BPE methods included are: Co-heating, Thermography surveys (& spot checks), IEQ monitoring (& spot checks, Overheating analysis (dynamic modelling), Energy modelling, Energy and Water monitoring, Thermal bridge analysis and Hygrothermal analysis e.g. WUFI[xxiii].

Case studies that demonstrate why BPE adds value

Direct Benefits

From 2010-15, Innovate UK invested £8m in a 'state of the art' comprehensive BPE programme that evaluated around 100 new-build projects across all four nations[xxiv]. These were split equally between domestic and non-domestic case studies, most of which are now housed on the Usable Buildings website[xxv]. Many are also captured in the BPN 'State of the Nation' housing website[xxvi]. Each case study demonstrates key findings and recommendations for clients, occupiers, the design team and policy makers. These findings enabled the fine tuning of housing design and performance by identifying significant improvements that could be made when designing, installing, commissioning and maintaining heating and ventilation systems. The direct benefits from the various BPE studies included:

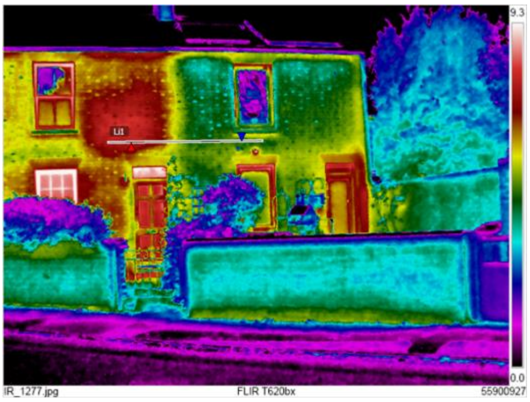
- improved design and construction detailing for new house types
- client, design and contractor organisational learning and team upskilling
- greater co-ordination and integration of construction and services
- improved thermal and acoustic insulation quality
- improved ventilation and heating system performance
- reduced occupant and landlord energy bills
- increased occupant comfort, health and safety
- improved accessibility to equipment for occupants and maintenance contractors
- increased occupant understanding of their home

CASE STUDY 1 mixed tenure new build

In a POE case study of 150 mixed tenure new-build homes built in Maidstone for Crest Nicholson PLC[xxviii], identification of hidden design faults helped the developer to refine and improve their house type. These included: removing an inaccessible roof lantern that was difficult to open or clean and poorly detailed, improving access to MVHR controls and units by ensuring they were not in an overly narrow cupboard space or in the attic, and reducing flexible ducting in MVHR systems leading to improved performance. Some of the initial performance issues were due to poor co-ordination of the services and structural elements. The housing developer subsequently changed their procurement process by creating a design panel of selected consultants which provided continuity from one project to the next and introduced a new organizational learning process that reduced defects. A new quality improvement process introduced direct reporting via digital tablets used on site. Improvements were also made to the handover process and home guide to help the residents understand how to use their homes more effectively.

CASE STUDY 2 deep retrofit

A deep retrofit of a typical 19th century end terrace house aimed for 80% reduction in carbon emissions, using the UK average figure of 97 kgCO2/m2/yr for a 1990's semi-detached house as a baseline for comparison, targeting 17-20 kgCO2/m2/yr, and 115 kWh/m2/yr for primary energy use. The BPE study[xxvii] included a 'pre-retrofit' study as well as 'post-retrofit' POE to help understand how the residents used the home in relation to energy use and take account of these factors in the retrofit design process. It also provided a true 'before and after' performance comparison in reality. The home achieved a 75% reduction in carbon emissions in real terms, but the study identified that some of this was down to the residents deliberately reducing space temperatures below normal standards and wearing warmer clothing. The study also highlighted relatively high CO2 levels indoors (1000ppm for 50% of occupied hours), despite the installation of an MHVR system. This was revealed to be largely due to the inhabitants not knowing how to use the system and not ever opening windows, as well as possible installation and commissioning issues.



Thermographic image of retrofitted insulation applied to 19th Century home.

CASE STUDY 3 housing association dwellings

A POE case study of new-build Code for Sustainable Homes Code 3 and Code 5 rented housing in Rotherham, carried out for The Guinness Trust Partnership[xxix] ,identified the inefficient high use of the immersion heater for hot water generation (1,470kWh) in one property (3A) for the first year of monitoring. After learning from this, the tenant started to switch items off and had new meters installed in order to keep closer controls on their energy spend. In the second year, electricity consumption was down by 41%, due to the correction of the controls set up and the reduced use of the immersion heater. The tenant was also found to be unaware of the MVHR system or its boost function, which was explained. In another home (5B) the tenant had an initial energy bill of £2,500 a year. The POE study revealed that there was a fault with the heat pump and that the internal thermostat temperature for the hot water vessel had been erroneously set to 80C instead of 65C at the commissioning stage. Once these initial issues had been identified and addressed, the energy use reduced by 30%.

Adding value through BPE partnerships

John Gilbert Architects have developed a unique BPE approach to evaluating the condition of existing housing stock and developing bespoke retrofit solutions[xxx]. They work in partnership with several local authority housing departments and housing associations at once over a period of two or three years, drawing on academic expertise from the Mackintosh Environmental Architecture Unit (MEARU) as required. This allows the client partners to learn from each other's findings, greatly increasing the value of their investment in the BPE processes. Selected BPE methods are carefully utilized over one heating season to examine specific areas identified by the clients as being of interest, with solutions devised, installed and monitored over the next heating season to check they are working. Shorter seasonal investigations over 4-8 months or 'snapshot' investigations over 3 months are also offered for examining specific elements of a building. The benefits of this approach have led to lower fuel bills for residents, less risk of fuel poverty, improved indoor environments for residents which have minimised health risks, better void management, technical assistance on repair options, and economical compliance with energy standards in hard to treat properties.

Overcoming current barriers

Costs

The cost of a comprehensive BPE study for a large project can add between 0.1% and 0.25% of the upfront cost to a project when it has not been planned for from the outset[xxxi]. However, costs can vary significantly depending on whether a 'light touch' post-occupancy approach is used, costing as little as £6,500 overall for a small development[xxxii] with virtually no equipment costs, or a more 'diagnostic' approach, as used in the Innovate BPE programme where monitoring costs averaged around £5,500 per home[xxxiii], largely because many studies did not plan for BPE from the outset. Much of these additional costs can be attributed to trying to contact the original people who hold the knowledge about what happened, particularly once the project team has been disbanded, as well as chasing up clients, occupants and design team members for various permissions and design information. If the POE part of BPE is built in from the start of a project, effective feedback loops can be designed into the existing project processes (e.g. accurate metering and data reporting) greatly reducing the cost.

Procurement

Traditional procurement contracts can set up adversarial relationships with design team members working in isolation and only sharing required contractual information. Under Design and Build contracts, novated design teams cannot inform the client of any changes made by a contractor that may affect building performance. An independent BPE evaluator needs to be included in these circumstances as part of the contract. There are now alternative 'partnering' contracts[xxxiv] which foster a 'no blame' culture which is conducive to BPE. Nevertheless, a major barrier to obtaining performance feedback is the lack of funding for POE activities in most government housing grants. This results in clients and design teams having to rely on ad-hoc funding when available, such as research grant funding via academia or government industry innovation grants.

Liability and Professional indemnity (PI) insurance

The advice of many PI insurers in the UK has been not to carry out POE, because this may highlight poor performance and satisfaction issues that would otherwise remain undetected. However, professional indemnity insurers are increasingly aware that POE is also about risk-mitigation and have started to allow POE, provided they are notified in advance, and that this work is carried out under a separate contract[xxxv]. Evidence shows that BPE projects do not generate litigation in relation to liability – they generate collaboration between clients and design teams to solve the issues identified earlier than would be otherwise[xxxvi]. Work is needed to convince all PI insurers to promote POE as a routine part of BPE.

Skills deficit

While most individual BPE methods can be undertaken by either a member of the design team or external experts, there is an urgent need for upskilling and training to create a new generation of designers who are able to lead and understand BPE as an integrated suite of methods that work together[xxxvii]. Currently few Schools of Architecture or Engineering teach BPE, as it is not yet mandated by Professional Institutions. The Architects Registration Board has included this requirement in its latest consultation on sustainability guidance for educators[xxxviii] which shows a change in thinking is happening. There is a need to promote BPE learning and teaching at all levels.

Developing a UK BPE resource and driving best practice

Many of the above challenges and opportunities are being addressed by the Building Performance Network (BPN) UK[xxxix] as national NGO dedicated to BPE. This organisation carries out research, promotes BPE best practice, and aims to provide a portal for information on BPE case studies and shared data to a strong network of clients, practitioners, contractors and policymakers. It is also developing a strong business case for BPE drawing on extensive evidence to demonstrate the added value it generates. We are asking for your support for BPE to be built into all Government funded building programmes (e.g., Social Housing Decarbonisation Fund), and the inclusion of BPE as a requirement in the Building Regulations, to ensure that homes are routinely evaluated during occupancy, in order to drive quality improvement and help ensure homes meet intended design, construction and installation standards. The forthcoming British Standard 40101 on BPE will provide a firm platform for regulatory compliance.

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