



All Party Parliamentary Group for Excellence in the Built Environment

Inquiry into the Quality of New Build Housing in England

Written evidence submitted by the Zero Carbon Hub

About us

The Zero Carbon Hub was established in 2008, as a non-profit organisation, to take day-to-day operational responsibility for achieving the Government's target of delivering zero carbon homes in England from 2016. Until recently we reported directly to the 2016 Taskforce.

The Zero Carbon Hub continues to work with Government and industry to identify risks, remove barriers to innovation and help demonstrate that energy efficient, healthy new homes can be delivered by the mainstream house building industry and in advance of the introduction of Nearly Zero Energy Homes from 1st January 2021.

Introduction

1. The Zero Carbon Hub has or is running a number of projects which relate to the quality of new build housing: the energy performance gap; overheating; and ventilation. We will discuss each of these in our submission below.
2. Rob Pannell, Managing Director at the Zero Carbon Hub, would be pleased to give oral evidence to the committee if this were deemed appropriate and desirable. Prior to joining the Zero Carbon Hub in 2008, Rob was a senior figure in the construction industry with over 35 years of experience with Taylor Wimpey UK Ltd, giving him a broad insight into the housebuilding sector. Specifically, Rob was responsible for design, construction and quality control to deliver 23,000 homes in 2007.

The Energy Performance Gap

3. A gap exists between the designed and as-built energy performance of new homes. By this we mean that there is a discrepancy in modelled energy use at the design stage, compared to the as-built stage (i.e. just before handover) of a dwelling. It is important to understand that the modelled energy use is based on a standard occupancy profile meaning that the impact of occupant lifestyle on energy use is taken out of the equation allowing the focus to be on the *potential of the home itself* to perform as designed.
4. Fundamentally what the existence of a performance gap means is that homes are using more energy (and emitting more carbon) than expected, occupants are paying higher energy bills than anticipated and the overall intended quality of the home could be jeopardised.
5. In 2013/14 the Zero Carbon Hub undertook a collaborative project with those involved at all stages of the housebuilding process, to start to uncover the extent and impact of the energy



performance gap in new homes. This revealed widespread evidence of a performance gap and that all stages of the process of providing new homes have the potential to contribute to it - from concept and detailed design, to procurement, construction, commissioning and verification. This could be inadvertently, as a consequence of conflicting drivers within the industry, or through poor practice. Three cross-cutting themes were identified as primary contributors to the problem: lack of understanding, knowledge and skills; unclear allocation of responsibility; and inadequate communication of information.

6. Although the Performance Gap project was carried out in the context of Zero Carbon Homes needing to deliver as-built performance, the government's decision not to improve energy-related standards for new homes in 2016 does not negate the need to deal with the performance gap. New homes are being delivered every day which are at risk of not meeting their design performance - whether built to 2006, 2010 or 2013 regulations.
7. Closing the energy performance gap as swiftly as possible is important because otherwise there are risks to the vital role buildings play in delivering the national carbon reduction plan. There are also consumer confidence and protection issues at stake.
8. The Zero Carbon Hub has published two reports on the issue; the first as a result of an extensive evidence gathering process which clearly showed that a performance gap exists¹; and the second 'End of Term' report highlighting areas for change and giving detailed recommendations for both industry and government². We would urge you to read these reports and have appended the Executive Summary of each to this submission (Appendix A & B).
9. The Evidence Review Report demonstrated that the Energy Performance gap is a pervasive issue within the housebuilding sector. A prioritisation matrix was developed for the issues that were identified (Figure 1).

¹ Zero Carbon Hub, *Closing the Gap Between Design and As-Built Performance - Evidence Review Report*, March 2014, available here:

http://www.zerocarbonhub.org/sites/default/files/resources/reports/Closing_the_Gap_Between_Design_and_As-Built_Performance-Evidence_Review_Report_0.pdf

² Zero Carbon Hub, *Closing the Gap Between Design and As-Built Performance - End of Term Report*, July 2014, available here:

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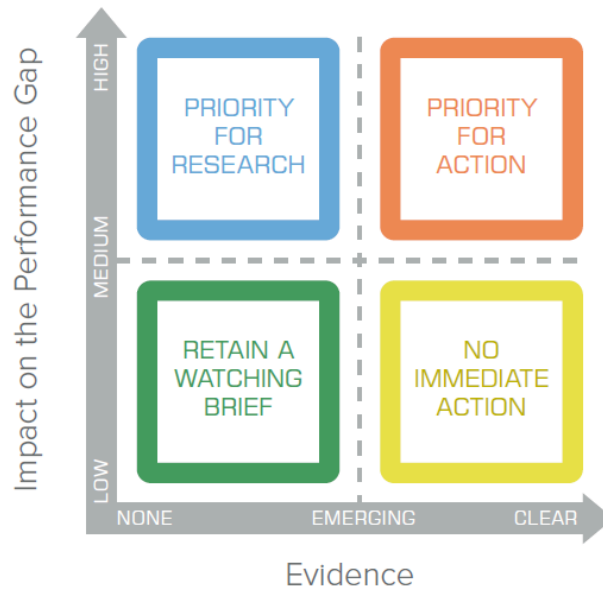


Figure 1: Prioritisation Matrix

10. The following 15 issues were categorised as 'priority for action' as they were supported by strong evidence from multiple sources and likely to have a significant impact on the Performance Gap. Figure 2 shows these in context across the delivery process.

- P2: Planning and concept design teams are not sufficiently aware of the implications of early stage decisions on the energy performance of completed dwellings.
- D1: Detail Design teams do not understand site and buildability issues well enough to be able to reliably design energy efficient homes with consistent as-built performance.
- D2: Different aspects of design, in particular building fabric and services, are not being properly integrated. This results in reduced build quality including unintended thermal bridging, compromised air tightness strategies and reduced system efficiencies.
- M8: Calculation assumptions for both fabric heat loss (U-values) and thermal bridging (Psi-values) do not reflect the reality of site construction, often giving lower heat losses than can actually be achieved (i.e, the assumptions are too favourable for general site practice).
- EM7: SAP assessors are often unclear on modelling conventions and calculation of U-values, thermal mass, and thermal bridging, and may be expected to provide detailed design advice beyond their technical knowledge and industry experience.
- PR2: Procurement teams do not prioritise energy related skills when selecting contractors, resulting in site teams that lack the knowledge to properly install services and fabric.



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- C5: Products with energy performance different to the intended design are being used on site without being fed back to the design team and the As-Built SAP assessment; typically foundation block work, lintels, windows and ventilation ductwork.
 - C15: Building fabric is often incorrectly constructed, typically cavity wall insulation, eaves to wall junction insulation and particularly the positioning of windows and doors, reducing the actual performance of the thermal envelope and impacting on quality.
 - C9: Building services are being incorrectly installed and poorly commissioned, resulting in reduced system efficiency and compromising the air tightness and ventilation strategies and build quality. Common examples include missing primary pipework insulation and poorly commissioned ventilation systems. There is a potential risk to health here if this leads to poor indoor air quality and increases the likelihood of mould growth.
 - C13: Site teams often lack the knowledge and skills to construct energy efficient homes with consistent as-built performance.
 - C6: Site Quality Assurance procedures prioritise other issues above energy performance; this increases the risk of improperly fitted insulation, incorrectly installed services and thermal junction detailing different to the intended design.
 - T3: Test methodologies for both as-built fabric and building services performance are not always consistently applied, and therefore can have implications on energy modelling assumptions.
 - EM4: As-Built SAP calculations are often produced without inclusion of amendments to the design specification during the procurement or construction process, so are not reflective of the actual build.
 - V2: Verification procedures across the housebuilding process are not prioritising energy performance. There is reliance on third-party information and inadequate time, knowledge and incentives to focus on as built performance.
 - V5: Inconsistent evidence is being requested by and provided to Building Control Bodies, in particular areas such as Accredited Construction Details and building services commissioning. This results in uncertainty around the actual constructed specification and energy performance.

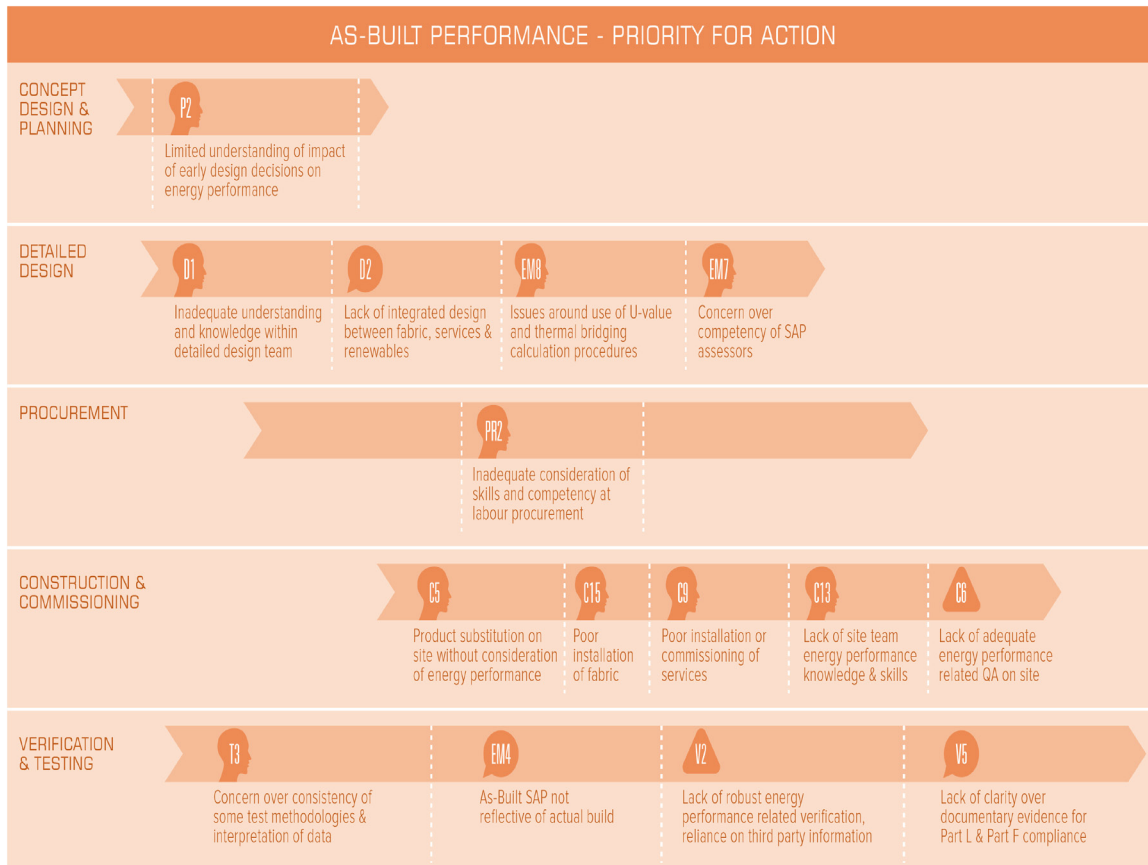


Figure 2: 'Priority for Action' issues

11. The End of Term report describes five areas for change, focusing on solutions to the issues identified. These are outlined below:

Energy Literacy

Across the whole construction industry there is limited understanding of as-built energy performance and the existence of the Performance Gap. Consequently there is an urgent need to emphasise energy performance issues in training of new entrants and to provide additional training and Continuing Professional Development for existing members of the industry. This includes clients, planners, designers, architects, engineers, SAP assessors, energy modellers, developers, contractors, procurers, site managers, materials suppliers, operatives, commissioners, testers, verifiers, valuers and insurance bodies. An industry recognised card scheme should be developed to enable operatives and professionals to demonstrate that they have the necessary energy performance knowledge and skills.

Improving Quality Output

There must be strong actions to improve as-built energy performance by encouraging design continuity, identifying responsibility for championing energy performance, introducing 'gateways' and improving learning loops. There is a need to create a more robust industry-led



approach to construction detailing, linked to improved quality control from design through to the construction and commissioning phase.

There is a clear need for manufacturers to address many areas of the Performance Gap, including via improved product labelling, design and installation instructions. Procurement teams need to prioritise energy performance when procuring materials and labour. Furthermore, improved quality control, from design through to the construction phase, is required together with rigorous independent commissioning of services.

National Compliance Method and Regime

The Standard Assessment Procedure (SAP) is a critical element within the assessment of a building's energy and carbon performance. Changes are required to increase the usefulness of the outputs for developers, designers, statutory bodies and occupants. A more comprehensive Product Specific Plain Language Compliance Report, signed by the housebuilder, should be implemented.

Conventions used for calculating key inputs related to both the fabric and building services need to be reviewed and in some cases linked to qualification schemes to ensure only those with sufficient knowledge provide this service. In a similar manner, the governance of SAP accreditation schemes, assessors and role of Building Control needs to be reviewed as the current schemes and inspections are clearly ineffective.

Demonstrating Performance

There is a clear need to refine existing diagnostic tests to make them more useful, usable and consistent, and to develop new techniques. In addition, manufacturers need to develop and adopt testing methods that better reflect the performance of their products as 'systems' within actual buildings. There remain conflicting views on the most commercially viable way to demonstrate a building's as-built performance, however the development of appropriate testing, measuring and assessment techniques is urgently required.

Continued Evidence Gathering

Expansion of the evidence gathering process carried out by the Zero Carbon Hub project is required to increase understanding of the Performance Gap and disseminate findings and feedback to developers, industry and government. In order to drive the cultural change required, it will be necessary to ensure this communication is targeted specifically to the different audiences.

12. The End of Term Report went on to give the following headline priority actions:

Priority Actions for Industry

To commit to providing the investment for:

1. PERFORMANCE ASSESSMENT R&D

Undertake the research and development necessary to create innovative testing, measurement and assessment techniques to understand the Performance Gap and develop



commercially viable methodologies acceptable across industry for 'demonstrating performance'.

2. SKILLS AND KNOWLEDGE DEVELOPMENT

Ensure that as-built energy performance knowledge, including learning from ongoing research and development, is embedded into training and up-skilling for professionals and operatives.

3. CONSTRUCTION DETAILS SCHEME

Develop an industry owned and maintained Construction Details Scheme providing 'assured' as-built energy performance for the most common major fabric junctions and systems.

4. CONTINUED EVIDENCE GATHERING

Support further evidence gathering processes and coordinated feedback to ensure accelerated continual improvement across all sectors of industry

Priority Actions for Government

To accept the Zero Carbon Hub's recommendations to:

1. SIGNAL CLEAR DIRECTION

Clearly indicate that, in place of immediate additional regulation, it expects the construction industry to act now and have put in place a number of measures to ensure that the energy Performance Gap is being addressed and to demonstrate this by 2020.

2. STIMULATE INDUSTRY INVESTMENT

Signal their long term intent, by funding research and development into testing, measurement and assessment techniques with immediate effect, to support the industry in providing the information necessary to quantify the Performance Gap and create the learning loops required to drive continuous improvement. Additionally, provide pump prime funding to enable industry to develop a Construction Details Scheme.

3. STRENGTHEN COMPLIANCE REGIME

Take action by 2016 to ensure that the Zero Carbon Hub recommended revisions to energy modelling practices, SAP processes and verification procedures, together with a strong regime to ensure that only suitably qualified persons carry out energy modelling and assessment, can be put in place.

4. SUPPORT SKILLS & KNOWLEDGE DEVELOPMENT

Accelerate the demand for industry developed qualification schemes by requiring energy certified operatives and professionals for developments on public land from 2017.

13. A 'route map to 2020' setting out the main actions was produced and is illustrated in Figure 3 below³. Much of the work indicated for 2014/15 remains to be taken forward. Regardless of the fact that there will be no uplift in Building Regulations standards for new homes in 2016, many of the actions remain urgent if the performance gap is to be closed and quality of new homes improved.

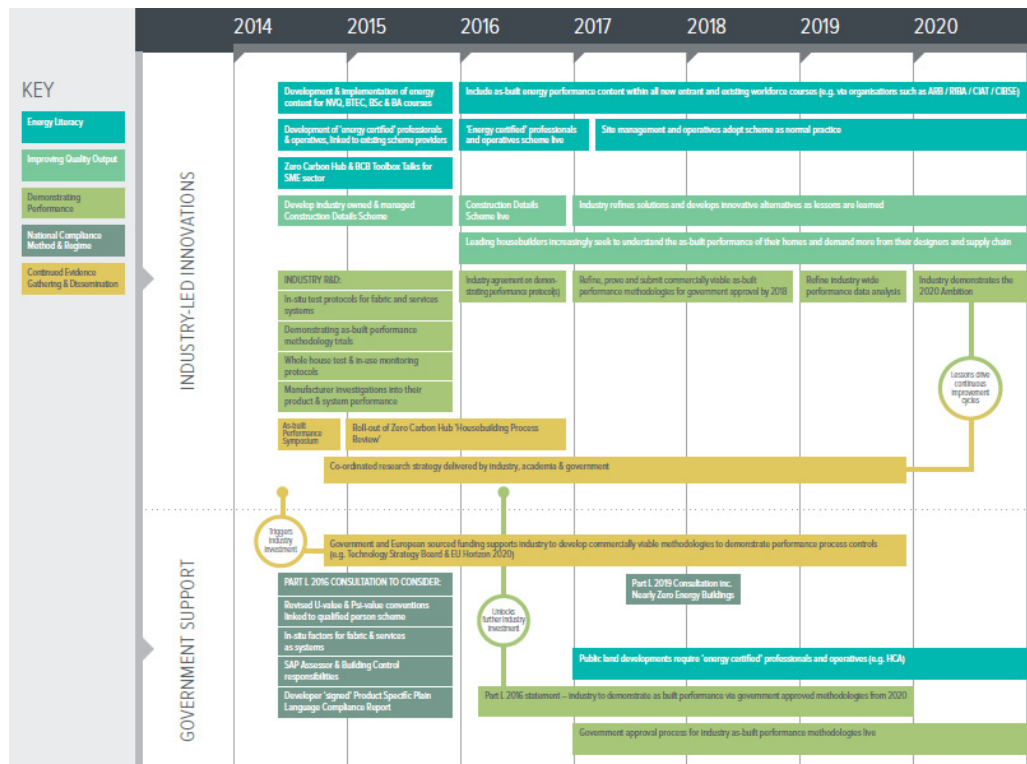


Figure 3: Route map to 2020

14. It is important to note that the issues described above have all been found in the context of an industry delivering homes at a pace largely dictated by the companies themselves. The current Government drive for greater numbers of new homes to be built will have a negative impact on build quality and the performance gap if urgent action is not taken.

Ventilation and Overheating

15. Just as important as the energy performance of new homes, is how comfortable and pleasant they are to live in. High quality new homes must be safe, healthy and comfortable for people to live in all year round.

16. The Zero Carbon Hub is currently working on projects designed to help government departments and industry decision-makers find practical and policy solutions to two issues which can occur in new homes:

³ For a larger (readable) version of the route map, please see Appendix C



- Temperatures inside a dwelling becoming too high (and staying too high) because the design of the building makes it hard for the occupants to prevent too much heat entering the building, and/or the design makes it hard for them to get unwanted heat out. This is called “overheating”.
 - Poor indoor air quality, caused by inadequate ventilation in homes – whether natural or mechanical.
17. We should stress that instances of poor indoor air quality and overheating are found in older buildings too. These issues are not limited to New Build housing, although some of the design preferences and legal requirements for newer buildings can make it even more important to ensure that overheating risk is assessed and managed, and that good levels of ventilation are provided for.
18. Thankfully, the majority of the population do not yet experience their homes being too hot in the summer, or homes being too stuffy with poor air-quality. But if not fully addressed by the sector now, these issues are expected to become much more commonplace in the future as the climate changes.

Overheating

19. At present, research estimates that up to 20% of homes (new and existing) in England already overheat, even in relatively cool summers. Overheating does not occur only during heatwaves. It can be a prolonged and difficult issue for occupants to deal with. Being unable to keep a home at comfortable temperatures can lead not only to sleep loss, reduced productivity and general discomfort, but also to illness and in some cases fatalities in vulnerable elderly people, those with chronic health conditions and young infants.
20. Overheating has not, historically, been something the UK housing sector has needed to grapple with to any great extent. Our existing leaky, cold housing stock needed attention, and fixing this was and continues to be high on our agenda.
21. The issue began to emerge in recent decades, driven in part by increased urban living at high density, new trends in building design, and an ageing population who are more vulnerable to the effects of excess heat. Experts and practitioners began to examine how to design and deliver buildings which are thermally comfortable in the summer, as well as in the winter, and to take steps to identify any potential for overheating to occur and reduce the likelihood of this happening.
22. When researchers have looked into why some buildings overheat, they usually find a combination of well-recognised causes related to how well buildings keep out unwanted heat from the sun, or how effectively the people living there can reject or purge unwanted heat from internal sources. This gives reason to be optimistic about housing providers being able to spot potentially risky combinations of location, orientation and building design early enough in construction projects to allow modifications to be made. In the majority of cases, the risk of overheating will be low and no further action will be needed.



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23. The Zero Carbon Hub published a report “Overheating in Homes – The Big Picture” on 16 June 2015⁴. The report is the culmination of a year’s worth of evidence gathering, industry interviews and surveys, and collaboration with government officials and industry partners – over 100 organisations. It describes the current state of knowledge on the issue at a national level, the causes, the extent of the problem, the impacts (for consumers, housebuilders and the NHS) and our level of preparedness to tackle the issue as a country.
 24. Our overall assessment is that although there are examples of good practice, this risk cannot yet be described as fully “managed” across the sector. Awareness of the potential for the problem and the damage it can cause is still relatively low. Even when housing providers have received complaints of overheating from their tenants or customers and want to sort out the problem, the institutional framework does not yet adequately support them in putting things right.
 25. The construction industry has responded in recent years to this challenge, in part, by developing “thermal comfort” temperature thresholds for use when designing new buildings. The Chartered Institution for Building Services Engineer’s (CIBSE) Guide A – Environmental Design (2015) is a good example. The guide advises that bedrooms and living rooms within a dwelling should stay within certain temperatures for specified periods of time. In the 2015 edition of the guidance, these comfort thresholds are allowed to vary depending on recent outdoor temperatures and the ability of the occupants to adapt their surroundings to stay cool - the “Adaptive Comfort Model”. An exception is made for bedrooms where an absolute threshold temperature of 26°C remains.
 26. Another basic “overheating check” used for new homes is contained in the Government’s Standard Assessment Procedure – at “Appendix P”. It requires energy assessors, when carrying out the SAP assessment for a property, to calculate the propensity of the building to overheat in June, July and August. If the average internal temperature (over day and night) is calculated to be above 23.5°C, it is determined to have a high risk of overheating. However, building designers use SAP Appendix P with some caution as it is not intended to inform design decisions.
 27. Lastly, the Government’s Housing Health and Safety Rating System (HHSRS) provides guidance for Environmental Health Officers to help them to assess whether a building may be hazardous to the health of the occupants. Again, this mechanism, although potentially powerful, is not intended to be an official overheating definition or “standard” and as a result is not generally used to guide the design of buildings.
 28. These frameworks form pieces of a jigsaw, but none represent an official, agreed sector-wide standard on overheating. The Committee on Climate Change’s Adaptation Sub-Committee recently called for such a “standard”. The Government’s response, published on 15 October 2015, acknowledged the issue and the work by the Zero Carbon Hub, and officials are now reviewing the possible next steps.
 29. The question now is what form a definition or standard would take and how it could be woven into industry practices as cost-effectively as possible. The question is important because the lack of an agreed, official definition means:

⁴ <http://www.zerocarbonhub.org/sites/default/files/resources/reports/ZCH-OverheatingInHomes-TheBigPicture-01.1.pdf>



- Housing associations and housebuilders lack clarity on what reasonable steps they must take and rules they should apply to safeguard their current and future occupants from overheating; and
 - Professionals tasked with assessing the risk of a property overheating may choose differing criteria to judge the performance of buildings, limiting comparison between them and generating anxiety about what the 'right' test to apply is.
30. If the goal is to deliver high quality, energy efficient homes which are thermally comfortable in winter and in summer, then agreeing what we are aiming for is a useful thing. However, we must also be certain that any future requirements are very carefully developed to avoid creating unintended consequences. Protecting the health of potentially vulnerable occupants must also be a consideration.
31. Research done to date provides a solid foundation for agreeing a sensible and pragmatic way forward, and the Zero Carbon Hub intends to bring together a group in December to coordinate thinking on next steps and support government and industry in solving this problem. We will produce a paper setting out preliminary recommendations for action in Spring 2016.

Ventilation

32. Similarly, there is a pressing need to ensure that the ventilation strategies in new low energy, air-tight homes work "as intended" based on the design at the completion of the building. Without properly functioning systems, indoor air quality is compromised, potentially leading to health issues for the occupants and damage to the building fabric.
33. A growing body of research suggests that problems introduced at each stage of the construction process, including the handover process to occupants and future maintenance, are creating a 'gap' in the actual performance of ventilation systems compared to the design intent.
34. To investigate this issue and allow the Zero Carbon Hub to make recommendations for policy solutions at the national level and practical solutions on-site, we are in the process of conducting a series of site visits to new developments in England and Wales to review how well ventilation systems have been designed, installed, commissioned and maintained. The results of this research will be written-up and available in Spring 2016.

Conclusion

35. It is vitally important to address the energy performance gap in new homes. This issue is intrinsically bound up in the resulting quality and comfort of the home. Closing the performance gap will enhance quality and improve the occupant experience. Many suggestions for how this might be tackled are contained within the Zero Carbon Hub 'End of Term' Report⁵.

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http://www.zerocarbonhub.org/sites/default/files/resources/reports/Design_vs_As_Built_Performance_Gap_End_of_Term_Report_0.pdf



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36. Similarly, efforts being made to ensure new and existing homes do not overheat and have good indoor air quality are crucial and necessary. However, we must also ensure that any new policies do not inadvertently damage the energy efficiency agenda by allowing the incorrect message to spread that “eco homes” are bad. This is not the case. Overheating has been observed in a variety of homes – new and old.
 37. There are still tens of thousands of “excess deaths” in the UK in winter, linked to people being unable to afford to heat their homes properly. Although this figure is coming down over time, the number of people living in fuel poverty is still unacceptably high. It is essential that standards on energy efficiency continue to evolve. Energy costs are forecast to rise rapidly over the coming decades and this could make a lot of homes, particularly in the existing stock, too expensive to live in. We just need to make sure the frameworks guiding housebuilding and retrofit also encourage designers and others to consider the potential for overheating and poor indoor air quality and mitigate those risks as far as possible as a standard part of their processes.
 38. England must now concentrate on developing standards for homes (and non-domestic buildings) which fulfil the requirements of Nearly Zero-Energy Buildings (nZEB), as part of the Energy Performance of Buildings Directive 2010/21/EU. Factoring in cost-effectiveness and feasibility, the UK has an opportunity to continue in its leadership role by supporting a tough but achievable definition of nZEB – nudging standards upwards from what exists today. This should take on board the recommendations on closing the energy performance gap and look to drive energy efficiency, comfort, well-being and quality in a more holistic way.

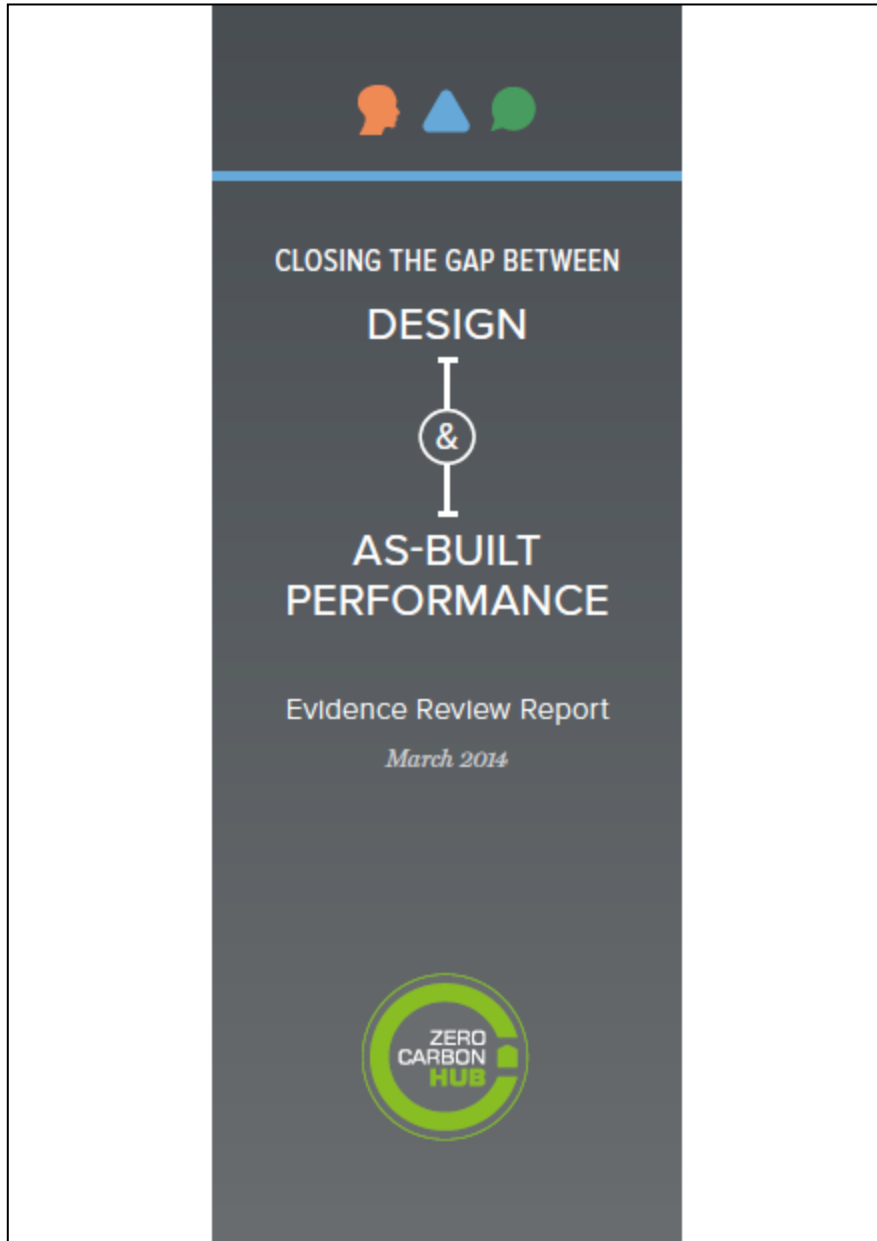


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Appendix A

Executive Summary of:





EXECUTIVE SUMMARY

There is now clear evidence of a gap between the designed and as-built energy performance of new homes.

This gap can arise in a number of ways within the overall house-building process and, if significant and widespread, represents a number of risks to government, industry and consumers.

In February 2011, a Zero Carbon Hub task group, having reviewed historical research¹ and gathered further industry evidence, advised that future performance standards for zero carbon homes should be linked to 'as-built' performance to achieve the '2020 Ambition'.

In response to this challenge the Performance Gap project commenced at the start of 2013, bringing a wide range of participants together to establish a better understanding of the Performance Gap and to formulate any necessary solutions. The initial activities and findings are detailed in the Interim Progress Report, published in July 2013.²

Closing the Performance Gap – the 2020 Ambition:

From 2020, be able to demonstrate that at least 90% of all new homes meet or perform better than the designed energy / carbon performance.

¹ Zero Carbon Hub, *Carbon Compliance for Tomorrow's New Homes, Topic 4: Closing the Gap Between Designed and Built Performance, August 2010.*

² Zero Carbon Hub, *Interim Progress Report: Closing the Gap Between Design and As-built Performance, July 2013.*

Evidence Review Report

This report summarises the evidence gathering and assessment process undertaken between August 2013 and January 2014. It provides industry and government with a structured review of how and where the Performance Gap occurs within the current housebuilding process. This has involved a co-ordinated analysis of published literature and confidential industry research, and the development of a process review methodology to gather primary evidence from housebuilding delivery teams, including visits to live construction sites.

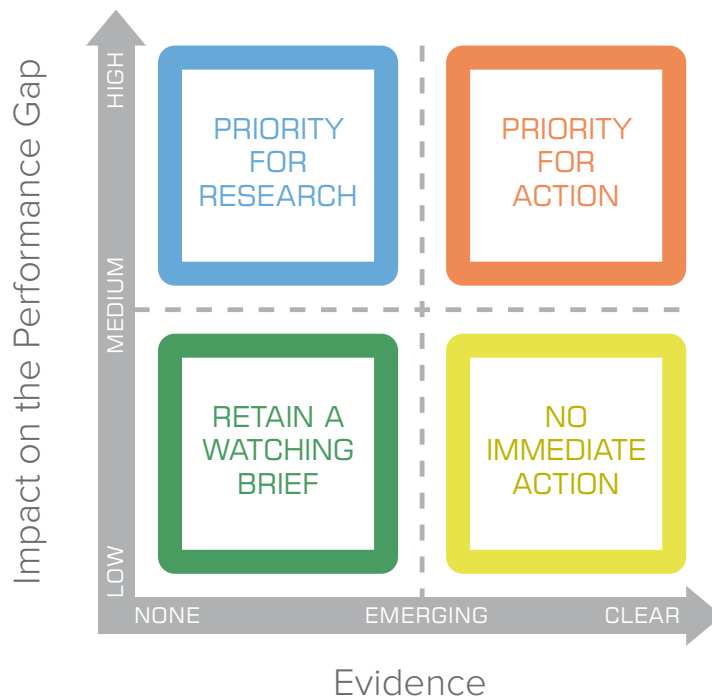
The evidence collected so far has been used to prioritise which issues are considered to be the major contributors to the Performance Gap.¹ The prioritisation process has been based upon the extent of evidence found and the significance each issue is considered to have on the Performance Gap.

Evidence Collection and Review

The evidence review encompasses a wider range of sources than any previous study of the Performance Gap to provide a balanced assessment of the issues. The aim is to consider the role all stages of the housebuilding process play rather than focussing on individual stages such as design or construction. This review has included:

- **Literature Review** in which nearly 100 reports were reviewed in detail. Around 45% were academic studies or other government or industry research, around 35% were building performance evaluation projects or other studies involving site visits and assessments of performance, around 10% were field trials, 5% manufacturer-commissioned reports and 5% guidance.
- **Housebuilding Process Review** made possible by housebuilders volunteering sites of varying sizes, types and construction methodologies. These were reviewed using interviews, a study of design information and site visits.
- **SAP Audits** undertaken for plots on each of the sites visited to investigate errors in SAP assessments and differences between the SAP assessments and site observations.
- **SAP Assessor Accreditation Organisation Questionnaire** to understand the training, examination and continual professional development regimes and to identify common areas of assessor errors found at audit and frequent questions dealt with by helplines.
- **SAP Assessor Questionnaire** to which around 150 assessors responded, providing information on how they typically work, what information they are provided with, what challenges they face and where a Performance Gap might occur.

1. A full list of these can be found in Annex A



Emerging Results

Drawing upon this evidence, a team from the Zero Carbon Hub and Steering Group categorised all of the issues identified using the prioritisation matrix approach presented in the Interim Progress Report (see diagram above). A ranking for the existence of evidence relating to each issue was agreed. A combination of multiple peer-reviewed industry research reports and Housebuilding Process Review examples were required to merit a position towards the right of the matrix. The team then drew upon the evidence where it existed, and their industry experience to define a range for the potential impact each issue may have on energy performance.¹

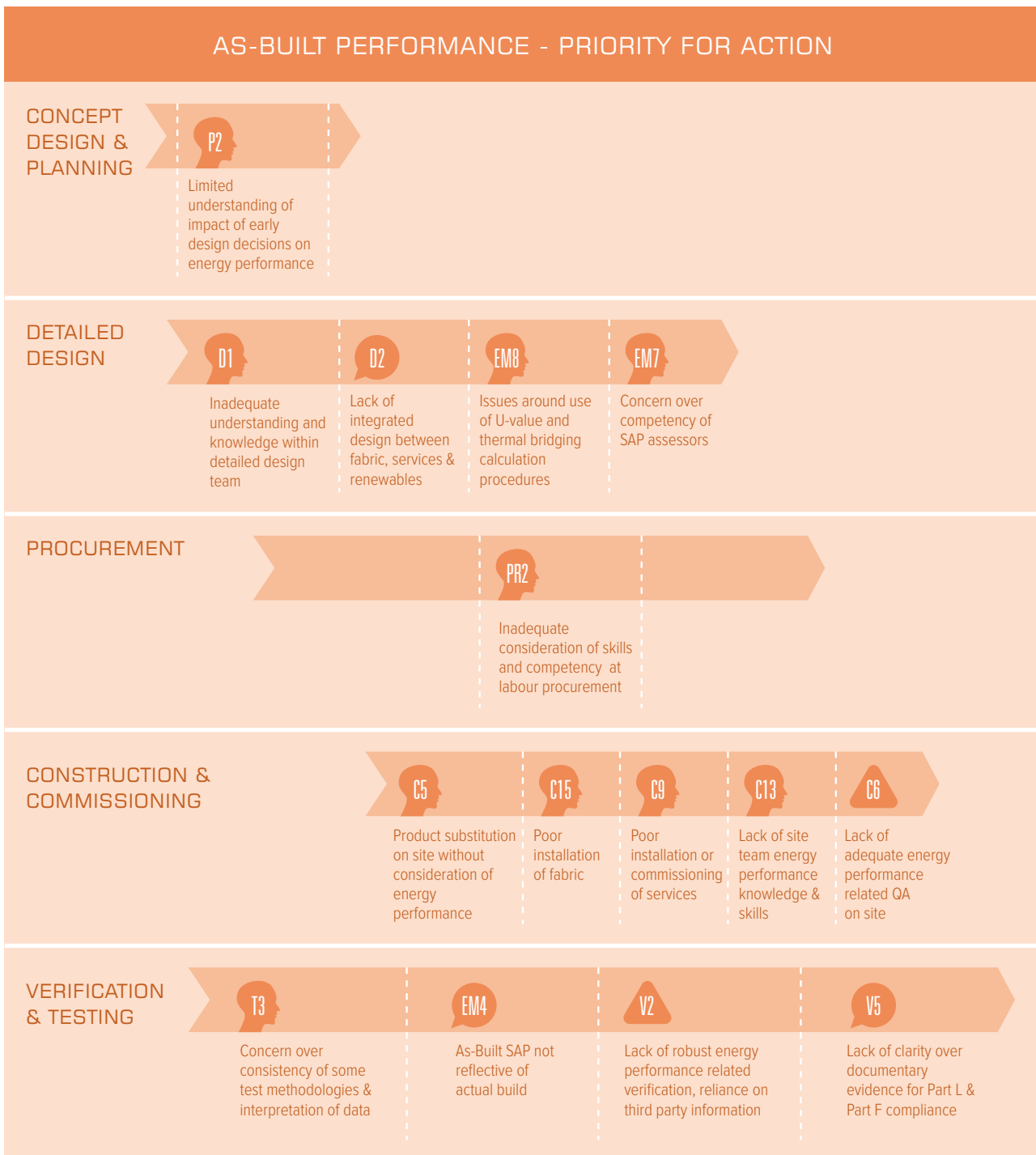
Each quadrant of the prioritisation matrix represents a different challenge:

- **Priority for Action** – Issues with a strong supporting evidence base and medium to high potential impact on the Performance Gap when they do occur.
- **Priority for Research** – Issues with emerging evidence and a suspected medium to high potential impact on the Performance Gap when they do occur.
- **Retain a Watching Brief** – Issues with limited evidence and a suspected low to medium potential impact on the Performance Gap when they do occur.
- **No Immediate Action** – Issues with a large degree of evidence but with a low impact on Performance Gap when they do occur.

This project's approach of viewing performance related issues across the housebuilding process revealed a number of cross-cutting themes including 'Knowledge and Skills', 'Responsibility' and 'Communication'.

¹. See Section 2 of the main report for an explanation of the rating process.

The following diagram illustrates where the 'Priority for Action' issues occur across the delivery process and how they relate to these cross-cutting themes.¹



CROSS-CUTTING THEMES



KNOWLEDGE & SKILLS



RESPONSIBILITY



COMMUNICATION

¹ The issue references relate to different stages of the housebuilding process (e.g. C = Construction). The full list of references can be found in Annex A.

Priority for Action – 15 issues

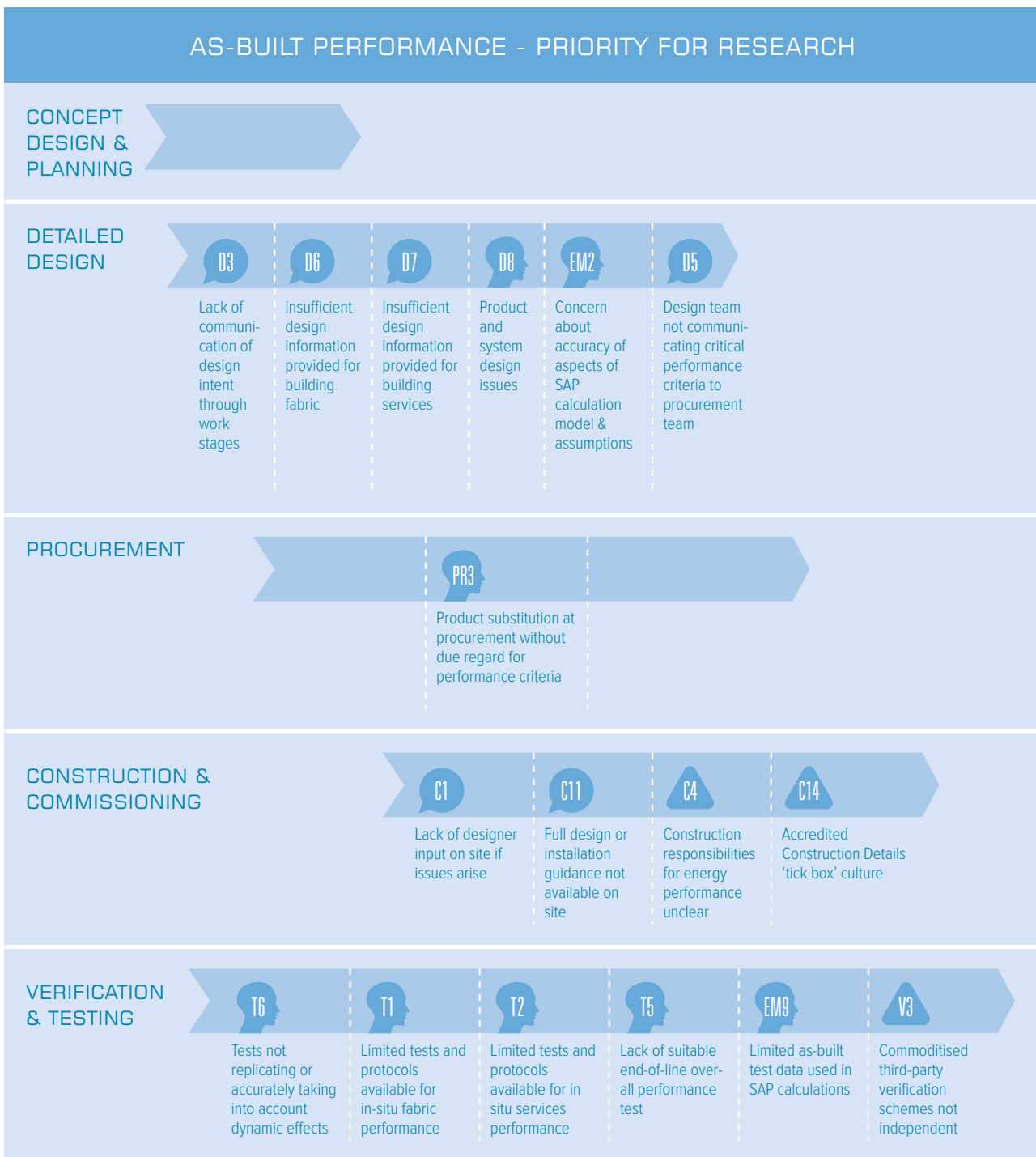
A total of 15 issues have been found to be both supported by strong evidence from multiple sources and likely to have a significant impact on the Performance Gap. The project will now focus its efforts on developing pragmatic solutions for the following issues across the delivery process:⁷

- P2** Planning and concept design teams are not sufficiently aware of the implications of early stage decisions on the energy performance of completed dwellings.
- D1** Detail Design teams do not understand site and buildability issues well enough to be able to reliably design energy efficient homes with consistent as-built performance.
- D2** Different aspects of design, in particular building fabric and services, are not being properly integrated. This results in unintended thermal bridging, compromised air tightness strategies and reduced system efficiencies.
- EM8** Calculation assumptions for both fabric heat loss (U-values) and thermal bridging (Psi-values) do not reflect the reality of site construction, often giving lower heat losses than can actually be achieved.
- EM7** SAP assessors are often unclear on modelling conventions and calculation of U-values, thermal mass, and thermal bridging, and may be expected to provide detailed design advice beyond their technical knowledge and industry experience.
- PR2** Procurement teams do not prioritise energy related skills when selecting contractors, resulting in site teams that lack the knowledge to properly install services and fabric.
- C5** Products with energy performance different to the intended design are being used on site without being fed back to the design team and the As-Built SAP assessment; typically foundation block work, lintels, windows and ventilation ductwork.
- C15** Building fabric is often incorrectly constructed, typically cavity wall insulation, eaves to wall junction insulation and particularly the positioning of windows and doors, reducing the actual performance of the thermal envelope.
- C9** Building services are being incorrectly installed and poorly commissioned, resulting in reduced system efficiency and compromising the air tightness and ventilation strategies. Common examples include missing primary pipework insulation and poorly commissioned ventilation systems.
- C13** Site teams often lack the knowledge and skills to construct energy efficient homes with consistent as-built performance.
- C6** Site Quality Assurance procedures prioritise other issues above energy performance; this increases the risk of improperly fitted insulation, incorrectly installed services and thermal junction detailing different to the intended design.
- T3** Test methodologies for both as-built fabric and building services performance are not always consistently applied, and therefore can have implications on energy modelling assumptions.
- EM4** As-Built SAP calculations are often produced without inclusion of amendments to the design specification during the procurement or construction process.
- V2** Verification procedures across the housebuilding process are not prioritising energy performance. There is reliance on third-party information and inadequate time, knowledge and incentives to focus on as built performance.
- V5** Inconsistent evidence is being requested by and provided to Building Control Bodies, in particular areas such as Accredited Construction Details and building services commissioning. This results in uncertainty around the actual constructed specification and energy performance.

The delivery process diagram illustrates that the majority of these issues result from a lack of 'Knowledge and Skills'. There is also a strong indication that the theme of poor 'Communication' runs through several of the Detailed Design and Verification issues. The cross-cutting nature of these themes means issues influencing the Performance Gap can be seen across the professions and trades.

⁷ A detailed description of the evidence review for each issue can be found in Section 3 of the main report, and discussion of next steps in Section 4.

The following diagram illustrates where the 'Priority for Research' issues occur across the delivery process and how they relate to these cross-cutting themes.¹



CROSS-CUTTING THEMES



KNOWLEDGE & SKILLS



RESPONSIBILITY



COMMUNICATION

¹ The issue references relate to different stages of the housebuilding process (e.g. C = Construction). The full list of references can be found in Annex A.

Priority for Research – 17 issues

A number of issues were identified that are considered to have a potentially significant impact on the Performance Gap, but for which we currently lack sufficient evidence to fully understand how extensive their contribution may be. This shortfall of evidence means these issues merit further investigation. There is a risk to industry and government that investment to develop solutions and research activities will be misplaced if these issues are prematurely considered of low importance.

The diagram opposite illustrates where the 'Priority for Research' issues have been identified. The project will continue to try and gather further evidence and develop longer term research strategies for these issues.

There is an increase in the frequency of 'Communication' themed issues within this diagram. It is perhaps not surprising that the evidence review has found emerging evidence of communication deficiencies. However, it is difficult to trace the root cause and detail of communication problems which bridge across multiple professions and teams.

Several Testing and Verification related issues are included, which are predominantly 'Knowledge and Skills' themed, indicating that there is a clear need to better understand the manner in which current methodologies reflect as-built performance. Further detail on which aspects of current practice require investigation and how they relate to design and energy modelling can be found in Section 3.

Retain a Watching Brief – 23 issues

A total of 23 issues have been classified as having a low level of evidence and likely to have a relatively low impact on the Performance Gap. Broadly speaking, little evidence of these issues was found across all sources; typically each one was raised in less than 20 medium quality reports in the Literature Review and identified in three or fewer of the sites visited. Further detail on these issues and an indication of 12 that are considered to merit closer observation is provided in Section 3.

Conclusion

The current housebuilding delivery process has been developed within a compliance regime based upon designed energy performance. However this evidence review has been conducted based on a vision of a future compliance regime focused on as-built performance. Therefore the findings should be considered with this in mind.

Having reviewed a large body of published research and conducted detailed investigations of nine current housing developments to date, with a total of 97 plots assessed, it is clear that many of the issues identified as potential sources of the Performance Gap do exist. Based on this evidence it has been possible to identify 15 issues that merit the development of comprehensive solutions in the near future, be they industry-led or where necessary involving government intervention.

These highest priority issues appear across the entire housebuilding process, for both developers using standardised housetypes and those using more bespoke designs. Consequently they are not the sole responsibility of any one discipline or sector. The theme of 'Knowledge and Skills' deficiencies is evident within all stages of the process, overlapping with other cross-cutting themes of 'Communication' and 'Responsibility'.

Another 17 issues have been prioritised as requiring further research in order to better understand their impact on the Performance Gap. Once again, many of these issues relate to a lack of 'Knowledge and Skills', particularly within the Testing and Verification stages. Of no less importance are the numerous issues relating to 'Communication' problems across the various delivery stages.

Next Steps

This Performance Gap project concludes in summer 2014, as part of the longer journey to 2020. Activity is now focused on continued evidence gathering and the 'Priority for Action' and 'Priority for Research' issues, as outlined below.

Continued Evidence Gathering

Evidence continues to be gathered and analysed, to allow a final review of the prioritisation of issues set out in this report.

In addition to the results from the first nine sites in the Housebuilding Process Review and associated SAP Audits included in this report, more are scheduled to bring the total to around 20. This will allow a range of construction types and housebuilders to be analysed: timber and masonry construction, large housebuilders and small. It is also proposed to carry out some on site testing of completed dwellings on these sites. The Testing Work Group have advised on suitable tests and protocols to use, covering both fabric and services performance.

A SAP Sensitivity Analysis is being carried out to understand the impact of potential input errors, including a consideration of the likelihood of these errors occurring.

Finally, a Work Group of building services specialists has been formed to ensure that all issues relating to services have been identified and to provide any further evidence that is available or needed to help understand the scale and nature of these issues.

Actions for Priority Issues

An Assured Performance Work Group has been formed to develop potential mechanisms that would demonstrate the '2020 Ambition': that by 2020 at least 90% of all new homes meet or perform better than their designed energy / carbon performance. These mechanisms also aim to provide industry with the necessary information to drive a continuous cycle of improvement.

Three further Work Groups are being established to understand how housebuilding delivery models of different scales and with different procurement routes could respond to the 'Priority for Action' issues, within the context of the work of the Assured Performance group.

Proposals will also be made for research strategies to address the 'Priority for Research' issues, with potential funding routes identified.

Final conclusions, proposed solutions and recommendations for further research will be detailed in the End of Term Report, to be published summer 2014.



Appendix B

Executive Summary of:



CLOSING THE GAP BETWEEN

DESIGN



AS-BUILT
PERFORMANCE

END OF TERM REPORT

July 2014





EXECUTIVE SUMMARY

Context, Future Vision & Drivers for Change

For some time, the Government has had concerns about the potential gap between design and as-built energy performance, following research into this issue by several universities and specialist projects. Indeed, such was its concern that it invested £8 million into a research programme by the Technology Strategy Board to look into Build Performance. The Government subsequently undertook a consultation into a regulatory option to help close the Performance Gap as part of the Building Regulations Part L 2013 review, which led to the Zero Carbon Hub being commissioned to undertake a full and comprehensive review of possible causes of and solutions to the Performance Gap.

This is also in the context of a previous Zero Carbon Hub Task Group which in February 2011 made recommendations as to the level of on-site carbon reduction ('Carbon Compliance') required for Zero Carbon Homes, based on closing the Performance Gap and achievement of the '2020 Ambition'.

This report draws together the findings of the Zero Carbon Hub project on Closing the Gap Between Design and As-Built Performance. It builds on two previous outputs; the *Interim Progress Report* (July 2013) and the *Evidence Review Report* (March 2014), together with subsequent work continuing the evidence gathering process and developing solutions to tackle various aspects of the Performance Gap.

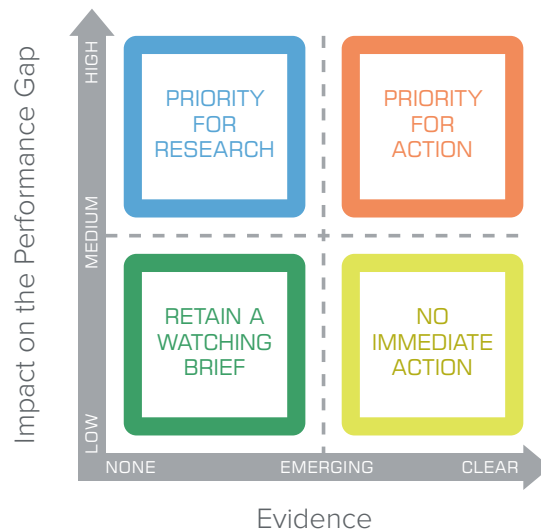
The project, commenced in early 2013, aimed to: review evidence for the significance of the gap; explore potential reasons for it; set out proposals to address the issues identified; establish areas for further research; and to put forward potential methodologies to enable the industry to demonstrate progress in achieving the '2020 Ambition'. It has been a collaborative process that has brought together a wide range of participants from across industry, involving 160 experts who have worked enthusiastically to provide evidence and solutions to the many diverse areas of the Performance Gap.

CLOSING THE PERFORMANCE GAP: THE 2020 AMBITION

From 2020, to be able to demonstrate that at least 90% of all new homes meet or perform better than the designed energy / carbon performance.

From a government perspective, a gap in a building's energy and carbon performance undermines its vital role in delivering the national carbon reduction plan, as well as presenting reputational dangers to the industry and undermining consumer confidence if energy bills are higher than anticipated. Identifying the origin, size and extent of any gap between design and as-built performance is, therefore, seen as a high priority for not only government, but also industry.

A list of potential issues creating this gap was drawn up, spanning the entire design and delivery process, from site acquisition, through design, to statutory approvals, procurement, construction and commissioning. A detailed evidence gathering process was then carried out, including questionnaires, an analysis of SAP, a co-ordinated analysis of published and confidential literature, and the development of a *Housebuilding Process Review* method to gather primary evidence from 21 live housebuilding sites from 13 developers. The issues suspected of contributing to the Performance Gap were then categorised, based on the strength of evidence and the relative impact of each. From this, 15 were defined as 'Priority for Action', a further 17 as 'Priority for Research' and the remainder as 'Retain a Watching Brief'.



The information reviewed and gathered revealed widespread evidence of a Performance Gap and that all stages of the process of providing new homes have the potential to contribute to it, either inadvertently, or as a consequence of conflicting drivers within the industry or through poor practice. Three cross-cutting themes were identified as primary contributors to the problem: lack of understanding, knowledge and skills; unclear allocation of responsibility; and inadequate communication of information.

A pan-industry shift in focus is required to create the necessary cultural change to address the issues identified. This will require a similarly systemic process to the embedding of health and safety within the industry consciousness and everyday quality processes.

The level of engagement in this project is a clear indication of the commitment by industry to close the Performance Gap, particularly from those companies seeking to deliver the highest quality low carbon homes but who are cautious about proactively marketing or guaranteeing as-built performance without being able to ensure consistent and demonstrable delivery in practice.

The scale of change in business practice envisaged within the tight timeframe of the '2020 Ambition' will only be possible if there are clear drivers to underpin it. In the context of pressures for increased housing supply and recent government efforts to reduce the regulatory burden, industry is also keen to embrace the opportunity to address the issue in a manner that is practically and commercially viable.

However, if a market advantage already existed for delivering high quality, low energy cost homes it would already be being exploited. Therefore it is believed that a clear regulatory commitment, appropriately designed, will help catalyse early action across the entire industry. A key aspect of any such regulatory driver must be the ability for industry to develop alternative approaches in a manner similar to the creation of Robust Details.

An example of industry developing innovative alternatives to regulation:

As a result of increasing occupant complaints, the Government announced in 2001 its plans to require post-completion acoustic testing under Part F of the Building Regulations. This galvanised industry to invest in innovative solutions to develop a more commercially viable method of demonstrating compliance. The resulting Robust Details scheme was launched in 2004 using a combination of type testing, process control and randomised end-of-line testing to ensure quality is maintained.

The success of such a period of rapid innovation is predicated on industry working together to demonstrate to government that it can improve and maintain quality outputs. Well targeted government funding for research and development, via bodies such as the Technology Strategy Board, is required to accelerate cross-sector innovations.

Areas for Change

A number of solutions, grouped into five key themes, have been proposed to address, in particular, the priority issues identified in the *Evidence Review Report*. These are outlined below and are summarised at the end of the Executive Summary. While some may apply across the entire industry, others may only be relevant to certain sectors, professions or organisations.

Energy Literacy

Across the whole construction industry there is limited understanding of as-built energy performance and the existence of the Performance Gap. Consequently there is an urgent need to emphasise energy performance issues in training of new entrants and to provide additional training and Continuing Professional Development for existing members of the industry. This includes clients, planners, designers, architects, engineers, SAP assessors, energy modellers, developers, contractors, procurers, site managers, materials suppliers, operatives, commissioners, testers, verifiers, valuers and insurance bodies. An industry recognised card scheme should be developed to enable operatives and professionals to demonstrate that they have the necessary energy performance knowledge and skills.

Improving Quality Output

There must be strong actions to improve as-built energy performance by encouraging design continuity, identifying responsibility for championing energy performance, introducing 'gateways' and improving learning loops. There is a need to create a more robust industry-led approach to construction detailing, linked to improved quality control from design through to the construction and commissioning phase.

There is a clear need for manufacturers to address many areas of the Performance Gap, including via improved product labelling, design and installation instructions. Procurement teams need to prioritise energy performance when procuring materials and labour. Furthermore, improved quality control, from design through to the construction phase, is required together with rigorous independent commissioning of services.

National Compliance Method and Regime

The Standard Assessment Procedure (SAP) is a critical element within the assessment of a building's energy and carbon performance. Changes are required to increase the usefulness of the outputs for developers, designers, statutory bodies and occupants. A more comprehensive Product Specific Plain Language Compliance Report, signed by the housebuilder, should be implemented.

Conventions used for calculating key inputs related to both the fabric and building services need to be reviewed and in some cases linked to qualification schemes to ensure only those with sufficient knowledge provide this service. In a similar manner, the governance of SAP accreditation schemes, assessors and role of Building Control needs to be reviewed.

Demonstrating Performance

There is a clear need to refine existing diagnostic tests to make them more useful, usable and consistent, and to develop new techniques. In addition, manufacturers need to develop and adopt testing methods that better reflect the performance of their products as 'systems' within actual buildings. There remain conflicting views on the most commercially viable way to demonstrate a building's as-built performance, however the development of appropriate testing, measuring and assessment techniques is urgently required to enable the '2020 Ambition' to be demonstrated.

Continued Evidence Gathering

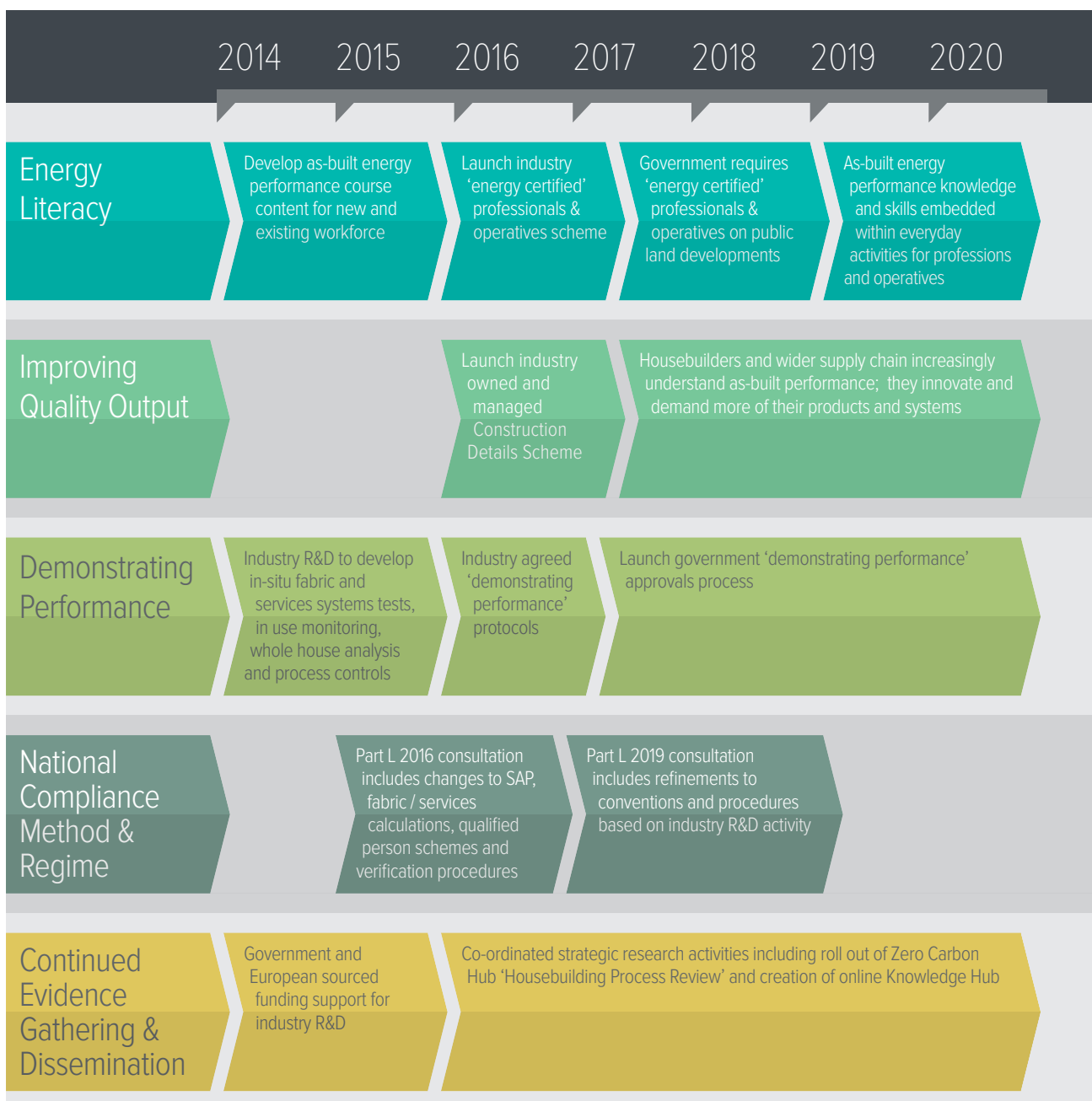
Expansion of the current evidence gathering process is required to increase understanding of the Performance Gap and disseminate findings and feedback to developers, industry and government. In order to drive the cultural change required, it will be necessary to ensure this communication is targeted specifically to the different audiences.

The initial ambition of the project was to undertake research and consider solutions that would, where possible, be cost neutral to industry. Whilst hugely ambitious, the project has indicated that although cost may be incurred in one area it is often offset in others. Certain improvements already undertaken by industry leaders have been undertaken at no cost but will have an immediate effect on the Performance Gap. These changes were instigated as a direct result of their involvement with the project's evidence gathering process.

Next Steps

As the construction industry develops products and processes capable of delivering homes with more predictable as-built energy and carbon performance, it will become essential that the research methods and tools used to assess them are continuously improved. Industry recognises the significant challenge the Performance Gap represents and the corresponding need to proactively address it. Rather than relying on ever more onerous regulatory interventions, industry is very capable of developing innovative, commercially viable methodologies to demonstrate their success.

This requires immediate co-ordinated pan-industry activity to trigger a cultural shift so that as-built performance becomes a core element of delivering high quality new housing. A strategically timed series of actions is therefore needed by industry and government between now and 2020, as set out in the summary Route Map that follows.



Headline Recommendations

The *Evidence Review Report* identified key areas that needed ‘immediate action’ and those needing ‘further research’, but it is clear that actions are needed by both government and industry if we are to close the ‘Performance Gap’ in the short to medium term. Indeed, the 18 months of discussion with experts has highlighted many ‘cross cutting’ themes and the overarching recommendations below should not be assumed to be exclusive and should be read in the context of the full report.

Priority Actions for Industry

To commit to providing the investment for:

1. PERFORMANCE ASSESSMENT R&D

Undertake the research and development necessary to create innovative testing, measurement and assessment techniques to understand the Performance Gap and develop commercially viable methodologies acceptable across industry for ‘demonstrating performance’.

2. SKILLS AND KNOWLEDGE DEVELOPMENT

Ensure that as-built energy performance knowledge, including learning from ongoing research and development, is embedded into training and up-skilling for professionals and operatives.

3. CONSTRUCTION DETAILS SCHEME

Develop an industry owned and maintained Construction Details Scheme providing ‘assured’ as-built energy performance for the most common major fabric junctions and systems.

4. CONTINUED EVIDENCE GATHERING

Support further evidence gathering processes and coordinated feedback to ensure accelerated continual improvement across all sectors of industry.

Priority Actions for Government

To accept the Zero Carbon Hub's recommendations to:

1. SIGNAL CLEAR DIRECTION

Clearly indicate that, in place of immediate additional regulation, it expects the construction industry to act now and have put in place a number of measures to ensure that the energy Performance Gap is being addressed and to demonstrate this by 2020.

2. STIMULATE INDUSTRY INVESTMENT

Signal their long term intent, by funding research and development into testing, measurement and assessment techniques with immediate effect, to support the industry in providing the information necessary to quantify the Performance Gap and create the learning loops required to drive continuous improvement. Additionally, provide pump prime funding to enable industry to develop a Construction Details Scheme.

3. STRENGTHEN COMPLIANCE REGIME

Take action by 2016 to ensure that the Zero Carbon Hub recommended revisions to energy modelling practices, SAP processes and verification procedures, together with a strong regime to ensure that only suitably qualified persons carry out energy modelling and assessment, can be put in place.

4. SUPPORT SKILLS & KNOWLEDGE DEVELOPMENT

Accelerate the demand for industry developed qualification schemes by requiring energy certified operatives and professionals for developments on public land from 2017.

This project has identified a number of key actions that government and industry are required to undertake. There is now a need for a concerted level of activity to implement the many detailed recommendations within this report in order to close the Performance Gap and demonstrate the '2020 Ambition'.



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Appendix C

Route map to 2020

From: Closing the Gap Between Design and As-built Performance, End of Term Report, July 2014

2014

2015

2016

2017

2018

2019

2020

KEY

Energy Literacy

Improving Quality Output

Demonstrating Performance

National Compliance Method & Regime

Continued Evidence Gathering & Dissemination

INDUSTRY-LED INNOVATIONS

Development & implementation of energy content for NVQ, BTEC, BSc & BA courses

Development of 'energy certified' professionals & operatives, linked to existing scheme providers

Zero Carbon Hub & BCB Toolbox Talks for SME sector

Develop industry owned & managed Construction Details Scheme

Include as-built energy performance content within all new entrant and existing workforce courses (e.g. via organisations such as ARB / RIBA / CIAT / CIBSE)

'Energy certified' professionals and operatives scheme live

Site management and operatives adopt scheme as normal practice

Construction Details Scheme live

Industry refines solutions and develops innovative alternatives as lessons are learned

Leading housebuilders increasingly seek to understand the as-built performance of their homes and demand more from their designers and supply chain

INDUSTRY R&D:
In-situ test protocols for fabric and services systems
Demonstrating as-built performance methodology trials
Whole house test & in-use monitoring protocols
Manufacturer investigations into their product & system performance

Industry agreement on demonstrating performance protocol(s)

Refine, prove and submit commercially viable as-built performance methodologies for government approval by 2018

Refine industry wide performance data analysis

Industry demonstrates the 2020 Ambition

As-built Performance Symposium

Roll-out of Zero Carbon Hub 'Housebuilding Process Review'

Co-ordinated research strategy delivered by industry, academia & government

Triggers industry investment

Government and European sourced funding supports industry to develop commercially viable methodologies to demonstrate performance process controls (e.g. Technology Strategy Board & EU Horizon 2020)

GOVERNMENT SUPPORT

PART L 2016 CONSULTATION TO CONSIDER:
Revised U-value & Psi-value conventions linked to qualified person scheme
In-situ factors for fabric & services as systems
SAP Assessor & Building Control responsibilities
Developer 'signed' Product Specific Plain Language Compliance Report

Unlocks further industry investment

Part L 2019 Consultation inc. Nearly Zero Energy Buildings

Public land developments require 'energy certified' professionals and operatives (e.g. HCA)

Part L 2016 statement – industry to demonstrate as built performance via government approved methodologies from 2020

Government approval process for industry as-built performance methodologies live

Lessons drive continuous improvement cycles