CLOSING THE GAP BETWEEN DESIGN AND AS-BUILT PERFORMANCE

NEW HOMES

INTERIM PROGRESS REPORT
APPENDICES

July 2013

The Zero Carbon Hub was established in 2008 to support the delivery of zero carbon homes from 2016. It is a public / private partnership drawing support from both Government and the Industry and reports directly to the 2016 Taskforce.

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Appendix A

BR443 workshop outputs

The table below is a record of the workshop held on 15th April 2013 to discuss *BR443: Conventions for U-value calculations* (2006), attended by around 30 industry professionals with knowledge of BR443 and government representatives.

The purpose of the workshop was to identify possible causes of the performance gap from use of BR443 guidance. This was carried out via a section-by-section facilitated discussion addressing the following questions:

- Is there an issue that could affect the performance gap? (**Yes**, **Maybe**, **No**)
- How much of an impact might it have on the performance gap? (**Large**, **Medium**, **Small**)
- How easy and quick would it be to revise the section? (**Easy**, **Middling**, **Difficult**)

Clause details	Is there an issue? R/A/G	How significant? R/A/G	How easy to revise? R/A/G	Comments
3.1 Thermal properties of materials & products: Declaration of thermal properties of products	R	R	R	■ Design v. declared values. ■ CE marked lambda values are unchangeable. ■ Take account of application of materials ■ 90/90 a good start.
3.2 Thermal properties of materials & products: Values for use in calculations	R	R	R	■ Lambda value can be modified. ■ BS EN ISO 10456 gives guidance for certain conditions (declared v. design). ■ Standard covers design to use needs review. ■ Low evidence base - Need case studies.
4.9.1 Issues concerned with U-values: Corrections to transmittance - Corrections due to air gaps in insulation layers	R	R	R / G	■ Corrections not reflective of actual on-sites gaps achieved. ■ What is standard workmanship assumed -must be practical. ■ Designers should expect issues when joining several layers together ■ Performance gap = significant issue ■ Revision (R) where hard to determine correction values, and (G) as easy for EN 6946
3.9 Thermal properties of materials & products: Thermal conductivity of other materials	R	R	A	■ Situation moved on - EN 10456. ■ What level proof req'd if falls outside standard? ■ Need to agree a form of words.
11.1 U-values for windows, roofs windows & rooflights - General	R	R	G	■ NARM recommendations under Part L ■ Aecom acceptance of NARM recommendations

Clause details	Is there an issue? R/A/G	How significant? R/A/G	How easy to revise? R/A/G	Comments
3.10.1 Thermal properties of materials and products: - Bubble sheet with aluminium foil facing	R	R	G	■ New standard for this needs referencing ■ New std. needs to be referred back to in declaration of emissivity (Sec. 4.8)
3.10.2 thermal properties of materials and products: - Multi-foil insulation	R	R	G	■ Merge with 3.10.1.
4.8.2 Issues concerned with U-value calculations: - Airspace resistance - Unventilated, low emissivity	R	R	G	■ Refer to 90/90 dec. of emissivity in EN 16012 ■ Quoted back stop values are safe. ■ EN 15976 testing of emissivity (inc. how to work ageing) - cover any product with low emissivity coating. ■ Angled applications? - better with interpolation
4.11 Issues concerned with U-value calculations: - Light steel-framed walls	R	R	G	■ Steel fraction issues. ■ Flag possible need for numerical modelling. ■ More guidance for hybrid systems - continuing to be developed by BRE/SCI.
2.2 Numerical methods and simplified methods: - Simplified methods	R	A	A	■ Competent persons to undertake calculations. ■ Two methods give different answers. ■ Ban use of simplified method.
2.4 Numerical methods and simplified methods: - Thermal bridging at junctions& around openings	R	A	R / A	■ Currently unaccounted for thermal bridges (e.g. bay windows, porch recess) not in SAP but needs to be implemented at change of regulation. ■ Need more psi values.
3.3 Thermal properties of materials and products:- Masonry	R	A	A	■ Data required
3.5 Thermal properties of materials and products:- Insulation materials	R	A	A	■ Need ref. to reflective products. ■ Ref to what to do if not covered by harmonised standards.
4.1 Issues concerned with U-value calculations:- Surface resistance	R	A	A	■ Values ok while air still. ■ Wind effects could be large (air-tightness) affected by temperature & wetness ■ EN 6946 windows & rooflights. ■ NHBC study on wetness & wind awaited. ■ This minuscule so irrelevant

Clause details	Is there an issue? R/A/G	How significant? R/A/G	How easy to revise? R/A/G	Comments
4.7 Issues concerned with U-value calculations:- Plasterboard wall lining	R	A	A	■ Assume airgap gives helpful resistance. ■ Is there an unventilated airspace? ■ Thermal laminated plasterboard to include fixings EN 6946. ■ If assuming best practice, values OK, but rest of doc assumes conservative values. ■ Include ICF & vacuum insulated panel - how likely for achievability on-site? - should there be testing? ■ As built v. as designed.
4.9.5 Issues concerned with U-value calculations:- Corrections to thermal transmittance - Rainscreen cladding	R	A	A	■ OK except for ref to CWCT guidance which might be over optimistic? ■ Where to stop counting?
4.9.9 Issues concerned with U-value calculations:- Corrections to thermal transmittance - Items that may be disregarded in U-value calculations.	R	A	A	■ Needs to be looked at.
4.5.1 Issues concerned with U-value calculations:- Timber fraction for timber- framed walls - Conventional timber studs	R	A	G	■ Need to justify fraction. ■ 15% reasonable. ■ Competence of person calculating. ■ Whether all data available? ■ Non-repeating need to be taken into account in psi values. ■ Ref to further calculation? ■ Procedural issues? ■ Add clarification & reflect other timber construction types (CLT, SIPS). ■ Ref work by UKTFA to provide info.
4.5.2 Issues concerned with U-value calculations:- Timber fraction for timber- framed walls - I-beams	R	A	G	■ Ref other web materials. ■ Similar issues as 4.5.1 - update to reflect process.
4.6 Issues concerned with U-value calculations:- Timber fraction for other elements	R	A	G	■ Include I-joist derivatives e.g. metal web.
4.9.2 Issues concerned with U-value calculations:- Corrections to thermal transmittance - Wall ties	R	A	G	■ Ref non-metallic wall ties. ■ Needs tidying revision - take out ref to wall tie area? But need default value. ■ Needs to be simplified or more comprehensive.

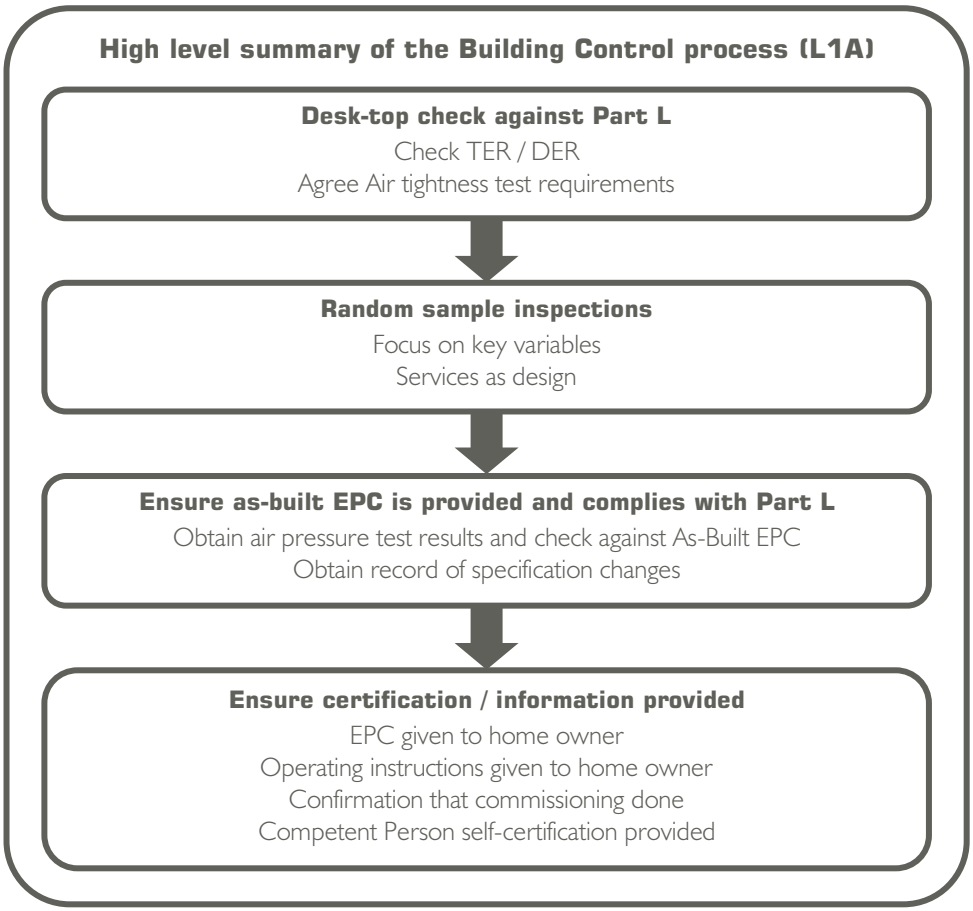
Clause details	Is there an issue? R/A/G	How significant? R/A/G	How easy to revise? R/A/G	Comments
4.9.3 Issues concerned with U-value calculations:- Corrections to thermal transmittance - Fixing screws& other discrete fixings	R	A	G	■ Not clear where fixing - windpost in innovative systems (steel web etc) & where modelling should take place. ■ Tube& recess fasteners.
4.9.7 Issues concerned with U-value calculations:- Corrections to thermal transmittance - Loft hatches	R	A	G	■ Increase table of insulation thickness ■ add conductivity of different insulation ■ add ventilation ductwork penetrations.
2.1 Numerical methods and simplified methods:- Numerical methods	A	A	G	■ Is simplified method acceptable for roofllights? ■ Differences with numerical & hotbox. ■ Clarity on applicability.
4.8.6 Issues concerned with U-value calculations:- Airspace resistance - Ventilated airspaces	A	A	G	■ Calculation of emissivity. ■ Need for new section on slightly ventilated air spaces where guidance is needed. ■ Tie together with emissivity of external surfaces.
4.10 Issues concerned with U-value calculations:- Metal-faced roofing & wall cladding	A	R	A	■ Check that MCRMA guidance referred to is up-to-date.
7. U-values for walls				■ Whole section to be reviewed
7. U-values for walls - Masonry solid wall				■ Advice about EWI systems, plasterboard on dabs (airgaps) - ref to dry lining. ■ Where to account for actual construction - quality of build & how to verify? ■ Correction factors related to type of construction & how to identify when to use which factor & don't currently have data to determine the factors & where should they be referenced (BR443/SAP?). We need data. ■ Implied tolerance = 0, is explicit statement of tolerance required?
7. U-values for walls - Masonry cavity wall - unfilled				■ Ventilated/unventilated cavity in reality?
7. U-values for walls - Masonry cavity wall - full cavity fill injected after building				■ Confidence factor needs to be applied under 4.9
7. U-values for walls - Masonry cavity wall - full cavity fill slabs after building				■ General ref to section 4.9 corrections? ■ Are sections 7,8 ,9 needed if competency scheme for U-value calcs is in place? &,8,9 used as sanity check?

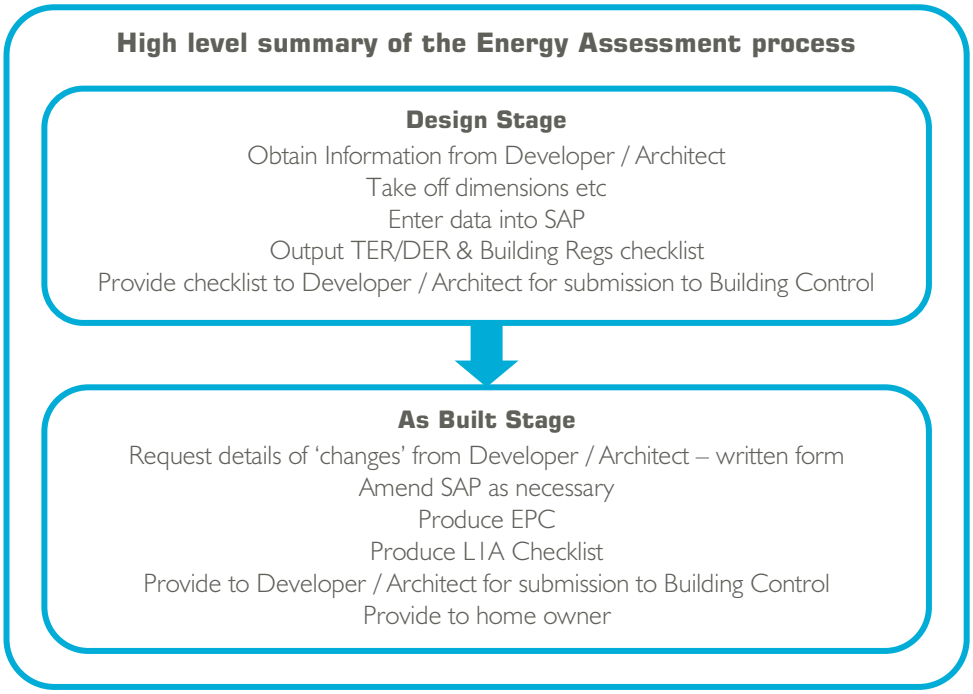
Clause details	Is there an issue? R/A/G	How significant? R/A/G	How easy to revise? R/A/G	Comments
7. U-values for walls - Timber frame wall - Insulation between solid timber studs (clear cavity)				■ Emissivity of timber frame wall needs to be considered & include panel systems.
7. U-values for walls - Timber frame walls - Warm frame and hybrid				■ Other types SIPS/CLT
8. U-values for roofs				■ Whole section needs reviewing
8. U-values for roofs - Inverted roof				■ Calculation for zero pitch required
9. U-values for floors				■ Whole section needs reviewing
9.2 Suspended floors - general				■ Guidance for where to include for edge insulation - U-value of psi value.
10. U-values for basements - general				■ Approved Doc for basements no longer available ■ Revision required ■ Ref to condensation risk check
12. U-values for doors				■ Recommendations put through Part L2013 consultation - await gov. reply
Appendix A				■ Covered by SAP
Appendix A - Other cases				■ Check with CIBSE Guide A & check applicability re 2013 U-values.
Section 1				■ Review as part of next revision

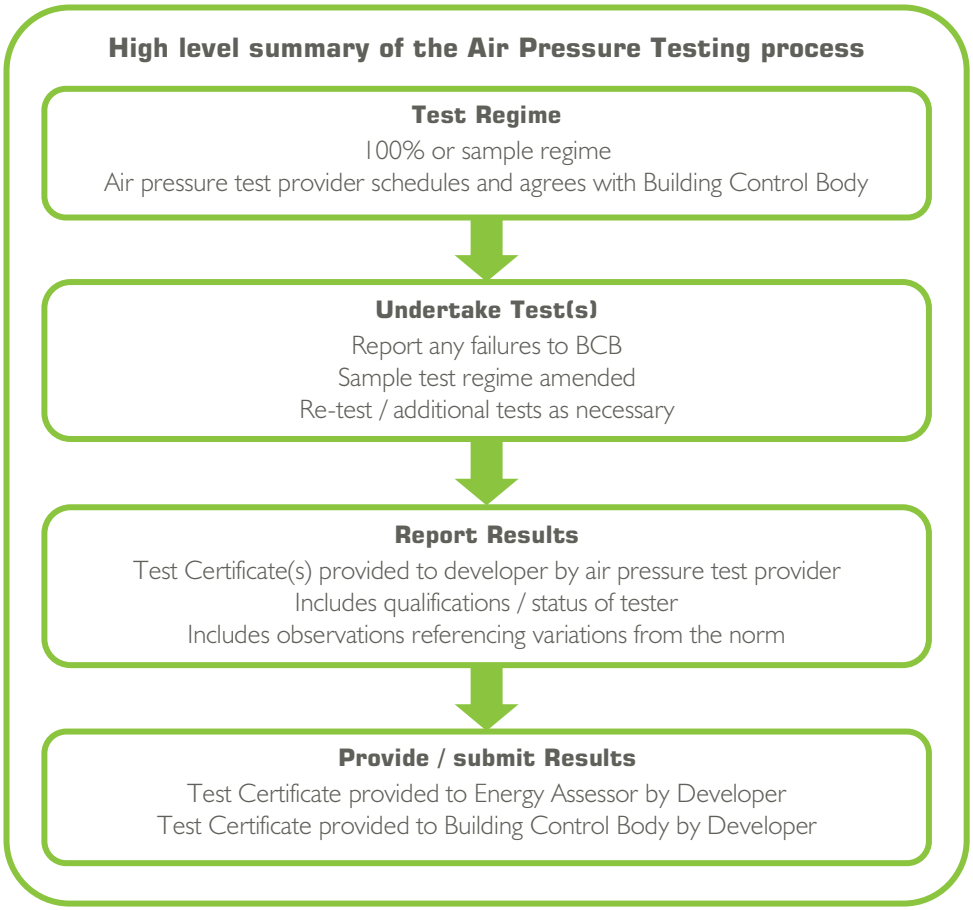
Appendix B

Verification processes

The diagrams below show the Verification Work Group's summary of the process of verification procedures for Building Control, Energy Assessment, and Air Pressure Testing.




High level summary of the Energy Assessment process
Design Stage
Obtain Information from Developer / Architect
Take off dimensions etc
Enter data into SAP
Output TER/DER & Building Regs checklist
Provide checklist to Developer / Architect for submission to Building Control
As Built Stage
Request details of 'changes' from Developer / Architect – written form
Amend SAP as necessary
Produce EPC
Produce L1A Checklist
Provide to Developer / Architect for submission to Building Control
Provide to home owner


High level summary of the Air Pressure Testing process
Test Regime
100% or sample regime
Air pressure test provider schedules and agrees with Building Control Body
Undertake Test(s)
Report any failures to BCB
Sample test regime amended
Re-test / additional tests as necessary
Report Results
Test Certificate(s) provided to developer by air pressure test provider
Includes qualifications / status of tester
Includes observations referencing variations from the norm
Provide / submit Results
Test Certificate provided to Energy Assessor by Developer
Test Certificate provided to Building Control Body by Developer

Appendix C

Review of test methods

The Testing Work Group has set out the following tasks to be undertaken in the project period:

- Carry out a review of:
  - What methodologies already exist, what their actual limitations are including a full uncertainty evaluation associated with those kinds of measurement, in terms of in-line and end-of-line testing
  - What methodologies exist but are not currently applied to the buildings challenge but have the potential to be e.g. MW generator, acoustic camera, THz imaging etc.
- Consider incentives for attracting people to take up appropriate testing for in-line and end-of-line application. Full supply chain to be considered if impact to be realised

The following tables summarise the Testing Work Group's review of the existing testing landscape.

Thermal Imaging

Gaps	Recommendations
■ One focus is about ensuring consistency. It is in fact possible to do TI under a range of non-ideal conditions – even outside of the winter and during the day – but the level of uncertainty increases and the skill required to interpret images also increases. There may be some occasions where it is in fact useful to image outside of the normal test parameters – the example of this is imaging under high wind speeds to identify thermal bypasses and ventilation heat loss paths. ■ As with co-heating and in-situ U-value analysis, TI can only be applied when there is a sustained and sufficiently high delta T and when specific solar radiation and moisture is available in the environment leaving a very small window of time to carry out the measurement. Certain times of the year preclude the use of TI (e.g. summer time) meaning application in the field is limited. ■ There is a gap in research in terms of quantification of heat transfer and u value studies using thermal imaging, particularly in the UK. Currently we are only effective at providing qualitative information but cannot effectively feed-back on qualitative performance as this requires not only correct weather conditions (as suggested above) but also consistency of application and interpretation of results which at present is poor. ■ A gap in our understanding on the whole of the parameters which need to be monitored within the building in order to best understand what the overall buildings performance is. From this what techniques should usefully be applied and what their limitations are. Thermal Imaging is one example. ■ Lack of enforcement with regards to consistency of application and interpretation of the Thermal Imaging technique and its outputs in order to make it useful in the field.	■ Review thermal Imaging alongside Non-destructive "look see" potential test methods to consider their case as a quick scan method for both in-line and end-of-line testing, from which more detailed investigation can and should be carried out.

In-situ U-value measurements

Gaps	Recommendations

■ Training on the use of HFM is straightforward but as with the Thermal Imaging, requires skill in the interpretation of data and results.
■ A clear knowledge gap exists in systematic evaluation of the impacts of different weather effects on thermal conductivity measurements. Such knowledge would provide confidence in basic data that underpin many of the models and our design assumptions. Testing of such impacts is dependent on a sufficient temperature difference between internal and external environments and as such this type of measurement is seasonally dependent.
■ The test is limited by the fact that:
  ■ There is a lack of standard practice in applying, using and interpreting information from HFM in real buildings
  ■ Hukseflux and similar HFMs only utilises a small sensor window and therefore measurement area. Matching the sensor variability with the expected variability of heat flow through the element – the trouble is we don't really know how in-situ heat flow varies in a real building
  ■ A lack of proper uncertainty evaluation
  ■ It cannot capture variability of performance across the envelope, or capture some more complex heat loss.
  ■ Energy performance of more complicated elements (i.e. double facades) cannot be captured at all using this test method.
  ■ The measurement time varies but on average takes ~10 days to carry out.
	■ There should be a full evaluation of the uncertainty associated with Heat Flux Meter measurements in order to maximise the effectiveness of the results of these kinds of measurements.
	■ Develop a standard protocol for applying, using and interpreting data from HFM in real buildings
	■ Design and deliver a programme of tests to introduce confidence into the use of as built u-values of elements of construction. The programme should replicate construction process and then use heat flux measurements to determine thermal conductivity of exactly the same structure under controlled and real-world conditions. This will required buy-in of full supply chain.

Lab-based U-value measurements

Gaps	Recommendations

■ The operation of a Hot Box is complicated and familiarity with the principles of U -value measurements is needed in order to maximise the usefulness of the output data.
■ Less mainstream/innovative materials take longer to be tested as standards are not readily available. Neither technique [HFM or Hotbox] covers dynamic effects. Recent testing used varying air speeds to simulate wind effects and temperature cycling to simulate changing temperatures on the external side to cover such effects.
■ Other effects such as solar gain can't be simulated via testing. Also, there is the possibility to measure mass transfer though the sample during measurement and this technique is currently under development.
■ There is a poor understanding of the effect of external wind speed versus the wind vector within the structure itself and how this affects the thermal conductivity of the structures.
	■ Carry out hot box measurements replicating real construction defects variations and density of different insulation types to fully understand the sensitivities of the U-value measurement to these parameters.
	■ 10 different samples including:
	  ■ Masonry cavity wall
	  ■ Timber frame
	  ■ Roof/floor
	  ■ Windows (in a wall and at junctions) /Doors (in Wall) [addressing elements not routinely tested]
	■ Consider overlap between this and DECC contracted work to BRE on similar issues.
	■ In carrying out this test programme consider
	  ■ Chamber testing
	  ■ Environmental impacts
	  ■ Correlation from onsite / Hot box / chamber measurement.
	  ■ Potential issues with site practice

Co-heating

Gaps	Recommendations
■ More research is needed to understand the reliability and uncertainty in the measurement. Leeds Met Protocol exists as guidelines but more guidance and consistency in method used is necessary. ■ As a measurement technique, the co-heating method captures all heat loss across the envelope. While this is an advantage in measuring more complex heat loss mechanisms often missed in theory and other test procedures, it is also a weakness as it is only a single number and cannot be broken down to understand where heat loss actually occurs. Further tools are needed for this. ■ As a (quasi) steady-state measurement, it also cannot be used to predict buildings performance under real conditions. ■ Further application of the method is limited by: timeframe (typical 1-3 weeks), reliability, reduced testing season (Oct-Mar), invasive (unoccupied dwelling), and understanding of uncertainty. ■ Co-heating is frequently misunderstood by people. Also the methodology defined by academics is good, but in terms of a fixed and detailed methodologies there are still gaps especially if widespread use is intended: ■ Equipment specifications are open to interpretation ■ Skills set definitions are incomplete ■ Data collection and analysis techniques are different in many studies (in terms of solar radiation, sensor placement etc.) ■ Clarity and consistency in the presentation of test results and their meaning, is missing? ■ The test is not elemental, it is based on a whole house value, so improvements to the building (to meet a standard etc.) are difficult to isolate. ■ Test process requires technicians who possess a combination of good construction knowledge and the technical skills and rigour to set up and maintain a complex test process. ■ Much is made of the relative lack of evidence of the performance gap – a bigger data set from co-heating would enable us to understand the distribution of performance and analysis of such data would enable us to target specific performance issues for more in-depth testing	■ A factual (anonymous) review of UK experiences with and outcomes from, co-heating tests to assess its viability as an industry test. ■ Consider factors such as simplicity to maximise uptake in post completion and pre-sale evaluation [with caution on the impact of settling on performance of the building]? ■ Push for better utilisation of co-heating test capacity to ensure as close to real data on performance of difference technologies is achieved. ■ Deliver a comprehensive test programme to produce a larger data set from co-heating

Elemental air permeability testing

Gaps	Recommendations
■ The measurements are not directly comparable and installation is a significant factor. This testing serves as a means for manufacturers to demonstrate that their products provide a reasonable level of air tightness and therefore will not adversely affect the overall performance of the building rather than providing assurance that because their product performs well under this test that using it in the building will improve the overall air tightness. ■ Testing of windows is compulsory in Germany but not in UK where we currently use calculated U-value measurements (see Thermal section)solar radiation, sensor placement etc.) ■ Clarity and consistency in the presentation of test results and their meaning, is missing? ■ Test process requires technicians who possess a combination of good construction knowledge and the technical skills and rigour to set up and maintain a complex test process. Requires experience of the test to make sure that measurements make sense.	■ Review standards that exist to assess air pressurisation of windows to see if they are able to withstand environmental factors (internal) and within it make the case for air-tightness testing of windows to be made compulsory (in both directions) ■ Consider the need for air permeability testing of all building elements such as blockwork, tiling, penetrations (eg soil vents) etc. Develop a benchmark value for acceptability.

Air permeability - Blower door testing

Gaps	Recommendations
Greater rigour is required in ensuring: ■ House pressure tests are good at measuring leakage - the issue here is about how the test data are then used to predict ventilation heat loss in SAP and other energy algorithms – the current methods are very simplistic, but there are more complex tools that use other factors to better predict ventilation heat loss at normal pressure differences. There is a need to review the assumptions in SAP and if there is a better way to use these data. ■ The testing is undertaken by component persons. ■ Results are visible for easier scrutiny by Building Control, including key aspects that may influence the result (eg an equivalent of Landmark for SAP). ■ That an appropriate number of tests are being undertaken. These improvements are being looked at by ATTMA and changes may be introduced to coincide with AD L 2013. In addition, the result is an indication of relative performance at an exaggerated pressure differential and there is limited data to specifically demonstrate the impact of air tightness on overall space heating requirements (some research has been undertaken by ATTMA) - current assumptions in SAP may require review based on 'real' data for the UK. Variability between different testing organisations due to inconsistent methodologies e.g. what was taped up and what wasn't (some tape up loft hatches etc).	■ Review of on-site supervision to ensure appropriate levels of engagement with testing process and consistency in the signing off of AP testing certifications and performance ■ Consider the validity of type-testing for factory built buildings or kits such that on-site air permeability testing is not required to satisfy building regulations

Ventilation

Gaps	Recommendations
■ Mechanical ventilation with heat recovery has stated performance requirement of >90% and to achieve a minimum of 70%. In reality, the actual outturn performance is unknown and testing is key to resolving this issue.	■ Full evaluation of how well ventilation ducts are designed and installed. Are there tests that can be applied to understanding the answer to existing questions on SAP. Building Service compliance guide ■ Consider testing involved in ensuring mechanisms meet standards. How can we be confident that performance is close to what it should be. ■ Establish or identify a commissioning test to make sure Design v As Built ventilation performance is achieved. ■ To identify a route to a DCV system being considered as part of the design process and achieve the SAP bonus points to be attractive. ■ Undertake a root and branch examination of the regulations, testing and specifications related to MVHR. Develop a simple, useable and robust means to design, specify, install and test these systems.

Indoor air quality

Gaps	Recommendations
■ Currently - SAP does not favour systems that try to use demand control ventilation.	■ Consider testing methodologies which allow agreement with performance requirement of Part F. Testing that exists for post occupancy that might be applied to pre-occupancy also. [Links to Air Tightness testing]

Building technologies / controls

Gaps	Recommendations
■ Currently limited capability or schemes for Independent Verification of Performance under real world conditions and in real world environments ■ Need to have a simple way of testing that the installation of technologies is performing as designed	■ Carry out a full review of core building GREEN technologies, installation inconsistencies, real world system performance, and interoperability

Feedback loop

Gaps	Recommendations
■ More testing of building elements to establish real performance and feed that into a calculation/design tool. And from that introduce on-going quality checks on building elements with the emphasis on quality assurance. ■ There are local- and internal-feedback loops but no industry wide feedback loop from which to derive a learning process for the full supply chain. ■ There is an inability to get an output at a sufficiently statistical level, such that everyone working on the house build, understands the consequence of their actions on the resultant buildings performance. Currently got a few co-heating tests which are statistically very small and poorly taken up. Air testing good example of where behaviours are changing. ■ If model (building physics) is accurate, focus on real tests which can be undertaken – can be fed back into the model and run the model again (and possibly continuously). Doesn't tell you where problem is but tells you if as built performance meets design. Outputs would be useful to householder also (smart metre type device). Also if put in place in 100 homes it would support the house builder. This would result in a good measure of performance from which forensic tests can be carried out as required. ■ Soft-landings offers a potential solution although weak because there is no imperative there is to use it. [Link to procurement: making decisions earlier in process]	■ Develop a process by which we formalise and encouraging feedback – Come up with a protocol for getting feedback from the right people to the right people. ■ Encourage a mind-set that transparency of lessons learned whereby the full community can learn preventing mistakes from being repeated – cultural change (supported by (1) being simple clear and consistently applied).

Appendix D

Evidence relating to Construction Joint Details

Section 1 – ACDs / ECDs accuracy and practicality

The current ACDs and ECDs can be criticised for either being dated or impractical to build. A few examples are given below:

Example 1 ACD MCI-RG-01 – a problem of averages

This ACD is not specific as to which type of block is used in this brick-cavity-block construction. The psi value quoted in Appendix K of SAP 2009 is 0.24W/mK. However if modelled using dense block the psi value increases to 0.37W/mK and if modelled using Aircrete block the psi value reduces to as low as 0.056W/mK. Thus whilst the ACD psi value is somewhere in the range of values achievable it does not reflect any one in particular.

Example 2 ACD MCI-IF-01 – conflict between regulations

This detail as modelled yields a psi value of 0.07W/mK again irrespective of the block density however the detail is considering thermal insulation only. When remodelled using a lightweight block to take account of sound insulation as well the psi value increases to 0.096W/mK.

Example 3 MCI-GF-02 – ACDs are not future proofed

This detail was probably modelled using a floor U-value in excess of 0.2. As limit values for building elements reduce (2010 is 0.2, 2013 is?) so the psi value increases. Thus the psi value applying to this detail in Appendix K is 0.16W/mK but if remodelled at a U-value of less than 0.2 the psi value increases to 0.24W/mK.

Example 4 ECD MV01 – Buildability - window frame – cavity overlaps

Heat loss at junctions between windows and the wall can make up a significant proportion of overall construction joint heat loss and both the ACDs and ECDs propose detailing to minimise such loss. In a traditional brick and block cavity construction the more the window frame overlaps the cavity – or the less it overlaps the outer brickwork the better will be the psi value.

The ACD for independent lintels (MCI-WD-02) requires that the frame overlaps the cavity by 30mm and would then allow a psi value of 0.03 to be taken when calculating the heat loss at the head. The ECD (MV01 Lintel B) for the same detail requires a frame to cavity overlap of 70mm and allows a psi value of 0.01 to be used.

However many current windows have frame widths of 50mm which would make fixing with a 70mm cavity overlap impractical and even if using wider frame widths (e.g. 100mm for some triple glazed units) can lead to a conflict between the cavity overlap required by the ECD and the brickwork overlap recommended by the window manufacturer.

Section 2 – Common Build Types

The working group considers that any remodelled ACDs should be of benefit to current users – especially the small to medium sized builder who does not enjoy the benefit of scale to afford bespoke modelling. As such, the Work Group sought evidence as to the main dwelling building methods in use today using the databases of two warranty bodies NHBC and FMB Warranty.

- The large NHBC data shows that for builders registering up to 50 dwellings a year the split of build type is broadly as follows:
  - Conventional masonry, 65%
  - Timber frame, 25%
  - Steer frame, 1%
  - Other (mainly concrete frame), 9%
- The much smaller but SME focussed data from FMB warranty tells much the same story with 90% of warranties issued being for masonry with the balance timber frame.

It is reasonable therefore to focus revised ACDs on the two main types (masonry and timber frame). Work is still on-going in the group to define whether a generic set of details for concrete frame construction is practical.

Section 3 – Information from WG4: Construction

A number of discussions have taken place within the Construction Work Group regarding the issue of construction joint details. The Work Group felt there is a need for a pattern book approach to construction detailing, to reduce potential for performance gaps, through linear thermal bridging heat loss. This is particularly relevant for the small to medium builder where thermal design understanding is likely to be poor. The Construction Work Group felt that this approach would be well received giving an alternative option for organisations which were not capable of calculating specific Psi values for their housing designs. This would build on the successful Robust Details acoustic accreditation scheme and align with practices which are already in use.

In the opinion of the Construction Work Group, key issues arising from this are:

Existing ACD's - A review of existing accredited and enhanced details, should be undertaken to gauge their appropriateness, relevance and uptake and whether these should remain or not. These are currently considered very poor and not reflective of common construction practise. The recommendation being these are reviewed, to establish if fit for purpose.

Approved Pattern Book - A separate scheme, comparable to RD Ltd, should be considered, offering a cost effective pattern book approach to approved details. An example of which is the work done by Constructive Details, for aircrete block systems. The recommendation being that this approach is fully considered and potentially introduced. This scheme should take into consideration:

- Building tolerances
- Various common build methods
- Workmanship
- Sequence of works, safe and practical access
- Design principles – Holistic approach to detailing, managing conflicts & priorities
  - Structural – Key consideration
  - Fire – Secondary principle
  - Acoustic , where required – typically compartment walls & floors only
  - CDM – safety aspects, sometimes considered
  - Thermal – often as an afterthought, token gesture
  - Practical Considerations – Generally not considered
- Changeable elements i.e. thickness, lambda, cladding finish etc.
- 3d Real life scenario vs 2d CAD drawn
- Hard to insulate areas – known problem areas
- Clash points – Typically service runs
- Compatibility with SAP Appendix K
- Ease of use, implementation & uptake
- Cost effectiveness

Appendix E

Evidence identified to-date

A non-exhaustive list of evidence sources identified and information collected to-date can be found below. It should be noted that the Evidence Manager will be speaking directly with Work Group Leads to ascertain whether Work Group members have other, potentially "secret" evidence that they are able share with the project.

Specific information collected and recorded by Work Groups to-date

Item / Report	Type of Evidence
Various thermography reports – Barratt, Stewart Milne, Redrow Homes	Field Trial, Compliance Process
AIMC4 Stewart Milne linear thermal bridging assessments	Compliance Process
AIMC4 Building Performance Evaluation Technical Report (To be issued July)	Field Trial
TRA Guidance on loft insulation	Guidance, rather than evidence?
Constructive Details – Examples of generic thermal bridging details	Guidance, rather than evidence?
UKTFA – Guidance on air tightness and thermal bridging	Guidance, rather than evidence?
Napier University – Report on predicted and measured U-values	Academic Study
BBA Information paper on air movement within loft insulation and thermal performance	Academic Study
BBA Information paper on reflective membranes on TF walls	Academic Study
Arup – Performance Gap report, Green Construction Board	Academic Study
EST Heat Pump Trials report	Field Trials
Stewart Milne Homes ■ Quality Alerts ■ Construction Standards of Excellence ■ Plot Inspection Books ■ MEV B-PEC commissioning reports	"Secret" knowledge
HM Government – Domestic ventilation compliance guide	Guidance, rather than evidence?
BSRIA – Flow measurement of domestic ventilation fans	Guidance, rather than evidence?
CITB – General requirements for fitting of loft insulation	Guidance, rather than evidence?
Barratt Homes ■ Best practise visual site board ■ Customer care reports ■ Training and inspection guides ■ Images of site construction mock ups	"Secret" knowledge
Review of construction types (NHBC and FMB data)	State of the Industry
Review of planning submissions (WG1)	"Secret" knowledge

It is noted that in a number of cases Work Group Leads have referred to papers or evidence presented at a Group meeting that is not explicitly referenced. A next step for the project's information manager will be to obtain these.

Publications containing evidence (non-exhaustive)

Title	Author	Date	Issue / Ref	Publisher
A Tale of Two Buildings - Are EPCs a True Indicator of Energy Efficiency?	Jones Lang LaSalle	2012		
Air Movement and Thermal Performance	BBA (British Board of Agrement)	8 November 2012		BBA
Architectural Science Review: The Usability of Control Interfaces in Low-Carbon Housing	Fionn Stevenson, Isabel Carmona-Andreu, Mary Hancock	2013		Taylor and Francis
BREDEM 8, A Monthly Calculation Method for Energy Use in Dwellings: Testing and Development	L D Shorrock, BRE S Macmillan, Eclipse Research Consultants J Clark, Cedar Design Systems G Moore, Middlesex Polytechnic	1991		
Building Confidence - A Working Paper	Dr A Stafford, Prof M Bell, Prof C Gorse, Leeds Metropolitan University	March 2012	Report no. 008	The Centre for Low Carbon Futures 2012
Building Information Modelling: An Introduction for House Builders	BSRIA Ltd	February 2013	NF49	NHBC Foundation
Building Performance Measurement	National Measurement Work	2nd August 2012		
Building Sustainable Homes at Speed: Risks and Rewards		February 2013	NF48 Research Review	NHBC Foundation
Carbon Compliance for Tomorrow's New Homes - A Review of the Modelling Tool and Assumptions	ZCH, NHBC Foundation	August 2012		ZCH
Designed for Manufacture: A Challenge to Build a Quality Home for £60k - Lessons Learnt 2	HCA	March 2010		Homes and Communities Agency (HCA)
DETR Framework Project Report: Field Investigations of the Thermal Performance of Construction Elements As Built	Sean Doran, BRE East Killbride	November 2000, revised June 2001	BRE Client Report No. 78132	BRE
EEPH/CLG Research into Complaisance with Part L of the Building Regulations for New Homes - Phase 2 Main Report	John Trinick, Elizabeth Elliott, Micheal Green, Jack Shepherd, Malcolm Orme from Faber Maunsell and AECOM	30th April 2009		
Evaluation of the Effect on Thermal Performance of a gap in the insulation of Laminate Thermal Board Internal Finish	Mark Primaroh, McCarthy & Stone	April 2013		Unpublished
Final Report: In-situ Monitoring of Efficiencies of Condensing Boilers and Use of Secondary Heating	Georgina Orr, GaC Tom Lelyveld, FM Simon Burton, FM	June 2009	GaC3563	The Energy Saving Trust (EST)
Flow Measurement for Domestic Ventilation Fans	Mark Roper, BSRIA	January 2013	Final Report 57015/1	BSRIA
Flow Measurement for Domestic Ventilation Fans - Tests on 15l/s fans	Mark Roper, BSRIA	February 2013	Final Report 57015/4	BSRIA
Getting Warmer: A Field Trial of Heat Pumps	Simon Green, EST Jaryn Bradford, EST	September 2010		The Energy Saving Trust (EST)
GHA Monitoring Programme 2009-11: Technical Report - Results from Phase 1: Post-Construction Testing of a Sample of Highly Sustainable New Homes	Peter Thompson, GHA Jon Bootland, GHA	2011		Good Homes Alliance (GHA)
Here Comes the Sun: A Field Trial of Solar Water Heating Systems	Jaryn Bradford, EST Frances Bean, EST Tom Chapman, EST Tom Byrne, EST	2011		The Energy Saving Trust (EST)

Title	Author	Date	Issue / Ref	Publisher
Home Insulation: A Report on the Call for Evidence carried out by the OFT	Office of Fair Trading (OFT)	August 2012	OFT1433	OFT Crown 2012
How the Green Deal will Reflect the in-situ Performance of Energy Efficiency Measures	Department of Energy and Climate Change (DECC)	October 2012		DECC Crown 2012
Learning From What We Build	Bill Bordass, William Bordass Associates	February 2003		W Bordass
Lessons from Stamford Brook: Understanding the Gap between Designed and Real Performance	Malcolm Bell, Jez Wingfield, Dominic Miles-Shenton, Tim South, Prof Bob Lowe	November 2008	Report No 8, Final Report	Leeds Metropolitan University
Lessons from Stamford Brook: Understanding the Gap between Designed and Real Performance	Malcolm Bell, Jez Wingfield, Dominic Miles-Shenton, Tim South, Prof Bob Lowe	November 2007	Report No 8, Final Report, Executive Summary	Leeds Metropolitan University
Low and Zero Carbon Homes: Understanding the Performance Challenge	Cutland Consulting Ltd	February 2012	NF41	NHBC Foundation ZCH
Low Carbon Housing: Lessons from Elm Tree Mews	Malcolm Bell, Jez Wingfield, Dominic Miles-Shenton, Jenny Seavers	November 2010		Joseph Rowntree Foundation (JRF)
Meeting Legislation and Enhancing Reputation: Working within the Contextual Pressures of Regulatory, Social, Economic and Other Drivers to Reduce Building Energy Consumption	Craig Robertson, UCL Energy Institute Dr Dejan Mumovic, UCL Bartlett School of Graduation Studies			
Micro-CHP Accelerator	The Carbon Trust	March 2011	Final Report	The Carbon Trust
Preventing Thermal Bypass in Party Separating Walls	Mineral Wool Insulation Manufacturers Association (MIMA)	November 2010		Mineral Wool Insulation Manufacturers Association (MIMA)
Review of Co-Heating Test Methodologies	BRE	Confidential Draft, March 2013		NHBC Foundation
Review of Differences between Measured and Theoretical Energy Savings for Insulation Measures	Chris Sanders and Mark Phillipson, Centre of Research on Indoor Climate and Health, Glasgow Caledonia University	December 2006		Glasgow Caledonian University, Crown
Temple Avenue Project: Energy Efficient New Homes for the 21st Century	Richard Partington Architects and Leeds Metropolitan University	2012		Joseph Rowntree Foundation (JRF)
Testing BREDEM 8 Against Measured Consumption Data and Against Simulation Models	L D Shorrock and J E Dunster, Building Research Establishment (BRE) C F Searle, H Eppel and K J Lomas, De Monfort University	1994		Crown
Thermal Conductivity and 90/90 Values	BBA (British Board of Agrement)	October 2012	Issue 1 No 55/12	BBA
Ventilation and Good Indoor Air Quality in Low Energy Homes	Melissa Taylor, GHA Dr Laura Morgan, GHA	November 2011		Good Homes Alliance (GHA)
Verification During Construction: Guidance to Support the Application of Reasonable Inquiry	Local Authority Building Standards Scotland (LABSS)	February 2013		LABSS, Crown
Whole House Heat Loss Test Method (Co-Heating)	Prof Malcolm Bell, Dr Jez Wingfield, Dr David Johnston, Dominic Miles-Shenton, David Farmer	March 2012		Leeds Metropolitan University

Appendix F

Work Group Proposals

The Work Group Leads, in conjunction with their members, have proposed work plans for the next project phase. These are presented below and provide an indication of the type of activities that may be undertaken following the evidence-based prioritisation, although it should be noted that these plans are not comprehensive. There are clearly crossovers between groups and therefore the Zero Carbon Hub team, in discussion with the Steering Group, will draw together the various proposed activities to ensure there will be no duplication of effort and that resources are directed in the most efficient way and towards the activities which will yield the greatest results.

It is important to note that prior to undertaking any of the delivery activities proposed by the Work Groups (as opposed to those relating to evidence gathering), a process of prioritising the issues that impact the performance gap will be carried out. Only activities relating to those issues considered to have a significant impact on the performance gap will be taken forward within the timescale of this funded project. The prioritisation process is explained further in *'Next Steps'* in the main report.

WG0 - Process

- Develop core generic process maps for Large and Small Developers
- Understand and map how different procurement approaches influence the process
- Refine the visual presentation of these maps to encourage wider industry feedback and as an aid to communicating clearly where performance gap issues may occur

WG1 - Concept and Planning

- Investigate what enhanced standards (beyond Building Regulations) Local Authority Planning Policies currently require, what form they require information in, how they assess it and how compliance is then followed through
- Continue to collect examples of schemes where early-stage assumptions were found to have fundamental problems when designs are taken forward to Building Regulations submission
- Think about what might be required of an early-stage 'design' tool – important characteristics, mechanisms to deliver, etc.
- Analyse typical forms, features and construction types for different orientations to establish relative impact on performance, to underpin a guide
- Analyse a sample of planning guidance to quantify potential impact of features and forms on energy performance and links to any performance gap issues.
- Source examples of useful existing guidance to use as potential templates
- Collect examples of information that was missing from early-stage proposals that disrupted later processes
- Survey Local Authorities and FIT/ RHI scheme to establish what auditing of renewable technology installations has been carried out and gain feedback on performance
- Gather evidence of issues that have arisen once the homes and shared facilities are occupied – in relation to on-going maintenance and usability
- Collect evidence on overheating (e.g. from GHA, NHBCF, RSLs)
- Review whether SAP building physics engine and assumptions are fit for current/ future purpose (Link to WG2b - Design & Assessment Tools)
- Investigate whether some technologies are over-rewarded in SAP (Link to WG2b - Design & Assessment Tools

WG2a - Design

- Map the range of new housing development processes to illustrate design procurement and design management through the process (Link to WG0 – Process)
- Identify case studies where disconnect between concept design target and subcontractor execution has led to blurring of liability and caused problems with delivery/ performance
- Consider how the process could be simplified – e.g. if standard details were available
- Identify improved design management processes – one that supports communication along the chain of responsibility
- Investigate the impact of different design procurement models on the performance gap
- Identify processes/ case studies where 'standard' or 'approved' details have been supplied as a key component of low-energy housing
- Develop an example of how building information modelling/ management can be used to minimise the discontinuities which can lead to a performance gap
- Reference designer issues from previous in-depth performance gap studies
- Develop recommendations relating to skills and knowledge requirements
- Help develop case studies showing how changes during construction impact on the design SAP and hence where greater checking might be required (Link to WG5a - Verification)
- Develop further case studies on the variability of SAP calculations depending on the quality of the inputs (Link to WG2b - Design & Assessment tools)
- Reflect on the role of the SAP Assessor in the design process and give recommendations (Link to WG2b - Design & Assessment tools)

WG2b - Design and Assessment Tools

- Carry out study to understand competence of Accredited SAP Assessors by comparing variation in modelling accuracy for a selection of example designs
- Undertake a desk based sensitivity analysis of how significant areas such as water heating, thermal mass and lighting are when modelling low energy homes
- Audit to understand the SAP related verification information flow from initial modelling to completion and develop a more robust process
- Survey SAP Accreditation Scheme members to gauge their understanding and interpretation of modelling conventions
- Carry out a desk based study of typical SAP Assessor input errors and their significance via Accreditation Scheme audit results including 'As Built' information trail
- Investigate ways forward regarding the reporting of in-situ performance of products/ systems (for input into SAP)
- Identify what else is needed to enable a better predictor of 'as-built' performance

WG3a - Materials and Products

- Undertake surveys of on-site construction staff and Building Control to get an idea of the scale and type of products that might be misidentified on-site, and follow up with interviews
- Check a statistically robust number of U-value and SAP calculations including a check on whether the as-built specification ties up with what was used in the submitted 'as-built' calculations

WG3b - Procurement

- Review tender documents and procedures used by members of the Work Group
- Review the differences in procurement processes between different size builders and how information and changes are communicated
- Assess how tightly specifications are controlled by Work Group members
- Discuss the critical role played by the quantity surveyor
- Gather information on the perceived knowledge gap of those procuring products and services

WG4 - Construction

- Liaise with BPEC, gas safe and MCS (Microgeneration Certification Scheme) approved installer schemes to review current information on installation of mechanical ventilation, heat pumps, waste water heat recovery and flue gas heat recovery and assess the need for improvements and link to EST/DECC Heat Pump Trial information
- Talk to NHBC and Building Control bodies regarding the inspection of insulation installations
- Work closely with the Construction Joint Details Work Group, especially on buildability issues

WG5a - Verification

- Review robustness of approval and surveillance of competent persons schemes in relation to Building Control
- Review and amend SAP Conventions
- Investigate how SAP modelling QA process can be strengthened
- Review SAP Conventions Group membership and make recommendations
- Make recommendations around the development of a competent persons scheme with UKAS accreditation for air tightness testing
- Consider whether Building Regulations should require air tightness tests to be undertaken by competent persons
- In relation to air tightness testing, investigate how the recording of variations from the norm (test procedures) can be made more robust
- Consider the concept of whole population sampling, statistical analysis and feedback loop as part of the 'verification recipe'
- Consider the merits of a proportional verification process that varies according to, for example, use of approved details, use of previously built and tested designs
- Consider the use of other techniques such as photographic evidence as part of the verification recipe
- Consider in-line air tightness testing as part of verification recipe especially where rates of 3 or below are targeted
- Consider further the concept of 'clarity of ownership'
- Consider what information should be submitted as part of a Building Control submission

WG5b - Testing

- Consider tests outside current built environment theme that might be applicable to performance gap issues (technology transfer)
- Refine recommendations and definition of appropriate delivery organisation(s) and associated costs
- Deliver a comprehensive report on what test methodologies already exist and their associated limitations including assessment of uncertainty associated with the test and secure funding to deliver
- Design and deliver a comprehensive test programme to embed confidence in the use of as-built U-values of construction elements and systems
- Design and deliver a programme of hot box measurements replicating real construction assumptions including 'defects' variations across a range of build types and construction elements (wall, floor, roof etc)
- Review standards that exist to asses air pressurisation of windows to see if they are able to withstand environmental factors (internal) and secure funding to do this
- Define a protocol which embeds a culture of learning and feedback

Appendix G

Record of initial WG brainstorming sessions

The initial meeting of each Work Group involved a brainstorming session of the issues perceived by the group members as potentially leading to a performance gap, within the particular focus area of the Group. Some images of these sessions can be found below. The tables which follow are a record of these "sticker" sessions.

WGO - Process

Concept and Planning

What	Who	How	
Viability	Land / Planning / Commercial	Land Acquisition File Decrease Gateway Process Decrease	
Agree Sales Mix			
Planning Policy Risk Management			
Constraints / Infrastructure	Engineers		
Agree Design Brief Prepare Concept Layout Community Engagement	Layout Designer Discuss House type Elevations		
		Submit for Planning	

Design

What	Who	How	
Fixed Concept Brief	LPA End User Client (Developer)		
Energy Policy	LA	Late	
SAP Model Code Level	Assessor	Workshops SAP Assessment Specification	
Planning Constraints	Planning Authority Client		
Overheating	LA	Large/Medium Builder proven process	
Cost	Cost Plan		
Preferred Construction Spec	Developer		
Aesthetics External Wall Developer	(Complex Design) PSI		
Specification (Detail design)	TMP (Kappa)	Standard Details	
Detail Design	Consultant Team Architect Planned - QS / MO	Proven Details Detail Design Process	
Materials	Supplier Data		
Details	(Skill Up or Skill Down) Co-Coordinator	Suppliers - BBA S / APP Q	
Sub Contract Design	Lead Role (Architect)		
Regulations	Buildability		
Budget	Valve Engineering vs Cost Cutting		

Materials, Products, Systems

What	Who	How	Gap
Invitation to Tender	Client/Design Team	Invitation to tender	Happens on every project or yearly if approved supplier status
Present Product / Risk / Services / Price	Manufacturer or Distributor	Presentations, Tender Docs etc	Value Engineering vs Cost Cutting
Performance Specification of Product	Specifier (Architect/Contractor/HB/HA) vs Client	Drawings (BOQ)	
Design/Detailing	Manufacturer	Technical Team	Supplier tied in due to level of service

What	Who	How	Gap
Quote/Drawings/Performance	Sales Team	Quotes	
Send/Install/Train Installer/Supervise	Manufacturer/Supplier	Guides and Manuals Academies nationwide	
Re design valued engineering services	Manufacturer/Design Team	Design office/On Site Meetings	Certification/Accreditation/ Standardisation
Build Completion	Contractor (HB)	Hand Over Docs	House Performance based on Lab tests or simply Standards created across Europe
Fabric	Manufacturer and Academies R & D EU Standards - game playing	U-Value Focus with little in-situ testing	Contractor/Sub Substitution
Traditional vs MMI	Traditional Components		Brand Supplier
Testing Bias (CAPEX)	or 'Equivalent' - equal approved	SAP	Services - hot water/heating/ PV etc (SAP)
Standard 'approved specification list'	Reliance upon Distribution Relationship	APT (air pressure testing)	Innovation Drive
Level of on-site support	Buyer Preference / Relationships	Low/Zero Carbon Technologies	

Procurement

What	Who	How	Gap
Product Specification	Architects Inform Procure-ment - is it consistent?	Architects Drawings	
Procure - products and service skills	Procurement Team	Supply Chain (tender process)	
Design done by service / product supplier	Supplier	Get Architect drawing	Supplier to design to core net performance
Does it meet spec?	Procurement Team	Using the spec given Employers performance	Does B.Regs assess 'system' design?
Product/Service Solution reviewed by design team	Procurement send to design and construction		
Summary of protect costed - cost reviewed	Procurement Team - business unit heads of dept.	Value Engineering	
Element - District Heating	Procurement Team		
Design Supply and Fix	Procurement Team	Tender	
Supply and Fix Materials and Labour	Procurement Team	Tender	
Supply Only (Labour)	Procurement Team	Tender	
Supply Only (Materials)	Site Manager	Local Purchase (Direct)	
Group Procurement Deals	Procurement Team	Tender	

Construction

What	Who	How	Other issues
Project Planning (Process)	Pm. Main Contractor	Plan	Do you think people know what they are look at? So much of the process is hidden
Install		Building Regs.	
Sub Contract		Site Detail Designs	
Materials Supply	PM/SCM (supply chain management)	Specification	
Snagging / Inspection	Main Contractor	Visual Inspection	
Site Materials Management	PM?	Site Plan	
Stats and Consents	Utilities		

Commissioning

What	Who	How	Other issues
Building Services	Builder, Electrician, Gas Fitter, Anyone?		MHVR - What happens when it doesn't work? O&M Setting on heating system at commissioning not changed Over Air tightness?
Handover?	?		
Ventilation	Sparky	DVCG BPEC	
Heating	Plumber	DHCG (Gas Safe)	
AOV (fire)	Electrician		
Controls	Several? No one?	?	
Testing: - Sound Tests - Air Tests			
Verification	Building Control		

WG1 - Concept & Planning

Theme	Issues
Overarching	■ The industry needs clarity on future regulation on energy and carbon performance (timing too)
Info requirements at planning. How much effort?	■ Need incentive to review compliance prior to making a planning application ■ Up to planning, house builders reluctant to employ full design team. Houses not fully engineered prior to planning ■ Planners should not prescribe method, ie fabric or renewables ■ What mechanisms are required (legislation or policy) to frontload a consistent measureable product through planning ■ Commercial pressure vs Need for detail at early stage ■ Req cannot be separated from risk
Tools	■ Lack of use of integrated design tools ■ SAP for early design stage ■ How can we simplify the technical across all professionals ■ Standard validation req at planning ■ How can we simplify the technical across all professionals ■ Standard validation req at planning

Theme	Issues
Planning requirement and how they are enforced	■ (outside London there is less resource allocation for this) ■ Planners should be balancing carbon outcomes with other planning objectives; often unaware of what efficient design looks like ■ Planning conditions? (too resource intensive?) Enforceable? ■ Planning/Building Reg issues ■ Complexity/Conflicts between multiple policy and building reg. requirements ■ Planners should not prescribe/specify technical performance ■ Reconnecting planning requirements and building regs. Targets expressed in building regs terms ■ Planning and Energy
Early stage design / purchase decisions	■ Build geometry (complexity = risk?) ■ How early do you need to consider energy / carbon; site acquisition, sketch schemes, planning app ■ What really matters at an early stage in order to achieve the required energy / carbon performance? ■ Masterplan - will depend on scale. Early engagement is key ■ Complexity is a cost - but may be a benefit ■ To de-risk site - need to consider all req. at inception ■ Greater role for LPA masterplans? resource issues? ■ Energy not a big priority in the development process - placemaking/sales and value come first ■ Site layout / topography? ■ Constraints have different weightings ■ Lack of feedback from design construction ■ At the moment, the industry doesn't set energy performance targets? How would a client specify this? ■ Constraint plans are standard = BARRAT/DWH ■ No penalty for non-compliance - no incentive to comply ■ Customers and estate agents don't know what low carbon means ■ Do we consider factors outside of the site that influence it? ■ Need better guidance on what Part L is used for - it is not a prediction tool
Making sure strategies will work in practice	■ Is there public awareness of performance gap? ■ Lack of forethought regarding detailing (not thinking through implications on energy targets of concept details) ■ Not enough attention paid to key service routes and interface with structural design ■ There should be more industry guidance on appropriate technology application eg Renewable and MVHR ■ Overheating needs consideration ■ Do we need homes designed completely differently? Shape, orientation, services, core ? ■ What are the risks? ■ Service cores air future proofing, but seem to add complexity and cost ■ It will become increasingly important to check overheating risk at concept and planning stage. Planners are not asking for this.
Process	■ How do you set up a project to make sure that initial thinking is followed through in practice?
Energy strategies	■ Key energy principles on table too late ■ Lack of involvement of technical expertise at concept stage ■ Fuel Availability

Theme	Issues
	■ Consider energy solution early ■ Will energy strategy endure? ■ Lack of synergy / awareness of local strategies ■ Consider cost to user
Other	■ Skills and knowledge innovation ■ Agents often inform the brief - they need to embrace change - need a hub to bring agents on board ■ In accessible information? Locals plans evidence base ■ Resource implications at developer and LPA level
Issues for other groups	■ Standard detailed energy assessment for planning ■ Do we need to distil SAP? ■ Annual monitoring reports ■ Design stage assessment should be a check on assumptions made at planning eg. SAP Assessment ■ How is local weather taken into account ■ There is poor handover between concept and detailed design ■ How can we evidence and operationalise the gap? ■ How is climate change taken into account in SAP? ■ Who takes ownership overall? ■ The construction industry would be more efficient is there were national construction standards ■ How should overheating be taken into account in SAP? ■ Define relevant construction standards

WG2a - Design

Theme	Issues
Skills	■ Lack of architectural design expertise ■ Skills and knowledge, training and motivation ■ Energy literacy? ■ More education required in tech managers understanding SAP - what it is and what influences it ■ Education of builders and installers of new tech ■ Build geometry (complexity = risk?) ■ Poor architectural design approach (not marrying the spatial / stylistic requirements with the energy / resource targets) ■ Energy tool assessors insufficient knowledge of systems?
Compliance Tool	■ Can carbon be simple? ■ Availability of info where needed ■ If SAP used properly in-depth then industry need to recognise time and cost ■ SAP Connections to include for more accurate measurement of volume ■ Can we trust SAP? Smaller designers have knowledge. ■ Energy tools are poor representation of district schemes ■ BR443 needs updating - how does it translate to designers? ■ Can we trust doc Q results on technologies?

Theme	Issues
	■ Heat loss from LTB - more junctions need to be included ■ How accurate are LTB figures in comparison to site? Is there any evidence? ■ U-Values for windows - only one ever used for whole house ■ PSI values ? ■ Checking tools for building control - detailed spot checks only on outputs ■ Not all services included eg cylinders - difference heat loss
Standard Details	■ How can we standardise design detail whilst allowing bespoke design when there so many variations to standards required by planners ■ Hard to insulate details - just accept? ■ Availability of standard details can help up-skill ■ Could components / standard details / junctions be 'compliant in SAP?' ■ Buildability ■ Do standard/robust details stifle creativity
Planning and Briefing / Procurement	■ Poor choice of consultants ■ Lack of clear brief to identify outcome ■ Too many standards - BRs/Code/Planning ■ Urban design impact/standards set up by local requirements - not able to deliver code ■ Planning briefs can result in unrealistic designs in terms of energy ■ Group buying agreements force design? ■ Unrealistic budget
Design Process	■ Lack of clear design documentation for procurement and construction ■ What is design? ■ Of the dwelling? Of the details? Of the materials? Of the construction process? ■ Other data - claims data ■ TA role of designers through the construction ■ Documents drawing - overload / case of use / KISS ■ Timescales for build don't allow feedback ■ Builder doesn't have the tech knowledge to make decisions that they are making ■ Lack of understanding of the wider implications of changes on performance of particular systems ■ Poor client specifications lead to lower quality builds ■ Cost alternative drivers not matched to objectives ■ Understanding of declared value (performance?) meaning ■ Could BIM revolutionise the process by providing continuity?
Compliance Process	■ Whose responsibility should it be? ■ Who check actual build v Design and what was input into SAP? ■ Building regulations farce? ■ Transitional provisions ■ Audit procedure for SAP assessment must be split pre and post completion ■ Self certification of design

Theme	Issues
Design Integration	■ Accountability of the stages ■ Substitutional systems ■ Integration of structure ■ Clash points not picked up ■ Services - integrated in design process? ■ Building services are often 'shoe-horned' into layout, reducing effectiveness ■ Is what's built respective of what was designed and accessed? Who checks? ■ I want a one off - I am special ? ■ Standard house types ■ Poor services design is often left to sub contractors and not integrated early enough ■ Understanding ITS (services and fabric) ■ Manufacturers of 'whole' house units requires a factory production control test of performance through the manufacturers ■ Control and supply chain ■ Buildability of design (key areas include insulation, air tightness, thermal bridging) ■ Conflicting building services ■ Communication of design and construction
Performance / Feedback / Users	■ Overly complex systems ■ Developer does not want it known ■ Unrealistic claims of performance - often resulting in last minute changes / poor performance / bad client experience ■ Lack of feedback about real performance of elements / services and user experience ■ Project after project reports on case studies ■ Solving a problem is not always the objective as problems are us - income generation ■ Risk to client of not achieving criteria until after completion (fingers crossed) ■ Lack of understanding user interface/usability ■ User sceptical of benefits of energy saving ■ Maintenance of services and systems ie. MVHR filters ■ House user behaviours conflicts with design
Other	■ Overheating cause? District heating, lighting, solar gains ■ Who is responsible for compliance?

WG2b - Design & Assessment Tools

Theme	Issues
Innovation - Products	■ New technologies have excessive numbers of assumptions where no field evidence exists ■ Appendix Q is driven by money - those that can afford to pay get in ■ Currently difficult to incorporate innovations ■ Accreditation to Appendix Q database is too slow ■ Must be sufficient 'evidence' to justify claimed performance
Weather / Overheating	■ Microclimate, local climate, considerations? ■ Weather data - even local weather data can differ to actual size

Theme	Issues
	■ Assumptions in SAP to be revised - weather, occupancy and values. ■ Weather assumptions vs As Built test weather ■ Avoid making compliance harder for certain regions whilst capturing differences ■ Overheating and climate assumptions ■ Large developments can better urban design deliver tangible energy benefits? If so how can we capture these into he tool? ■ SAP overheating is simplistic and generally considered inaccurate and also not taken seriously as EPC QA does not cover - regs only ■ Actual solar gain can have a huge impact on performance ■ Agree that solar shading of windows is very simplistic
Tool accuracy vs Complexity	■ Include error calculation as part of tool ■ input error ---- model ---- model error ■ 'Loop Holes' - thermal mass, PSI valves, sign off, what driver? ■ Heating efficiency system is not measured, only boilers ■ Must avoid over complicating SAP - must be a limit to the level of detail ■ Does appendix Q work? To help the SAP calc? ■ Defaults cause errors unless picked p on the 'AP Built' stage ■ Definition of room types is poor - only living area ■ Should the design tool be separate to the compliance tool? ■ SAP default need to be worse case (and encourage better design) ■ Is SAP too simple? To give an accurate calculation? ■ What level of energy knowledge/practice should be assumed when deciding inputs to the model? ■ More transparency in SAP required ■ How would this help? Highlight the amount that is assumed ■ Expand PCDF to increase accuracy and minimise data entry ■ Community heating calcs are very generic ■ Is community/district heating beyond SAP?
Skills & Knowledge	■ Skills and knowledge, training and motivation ■ Do QS understand implication of changing specification. Value engineering? ■ Role of SAP assessor in 'design' - is this good advice? Are they qualified to give ■ Building Control take SAP assessors output as gospel - rarely challenged or compare to on site. That's because they are not SAP assessors and are not responsible for compliance
Feedback	■ Lack of info back to assessor for as-built SAP ■ As built based on builder honesty site visit by assessor ■ Home buyer 'extras' selected during sale not taken in final SAP ■ Do these influence as-built performance is only looking at pre-occ ■ Difference SAP assessors will accept different levels of documentary evidence from builders
What are we trying to understand?	■ Design WG ask; Want designer friendly tool which will output compliance check ■ Compliance tool not designer friendly enough - need to see impacts of spec changes etc ■ Compliance vs Design Tool ■ What are we measuring?

Theme	Issues
	■ What are we trying to understand / measure? ■ Is there nay point calculating HWS demands. HWS is based on floor area not L/P/D rates ■ How can industry have confidence in products/tools and their stated values? ■ Product performance calculated methodologies should fall within the boundaries/preview of the tool ■ SAP could output basic design advice eg overheating risk and suggestions; air quality warnings ■ SAP is a compliance tool ■ Not currently suitable for predicting as-built performance ■ May be suitable with inclusion of model error ■ Weighting of input variables ■ What does it matter? Buildings don't produce CO2 - humans do.
Dynamic Effects	■ Are important dynamic effects taken into account? ■ Use statistical measures based on empirical data - physics is too complicated ■ Steady state compliance tool only ■ No evidence that this is actually a problem
Input accuracy and tolerance	■ Insulation gaps - wind? BBA report ■ Any more 'unknowns' - importance of calibration tests ■ Lack of calibration between simulation and outcomes ■ Need for review of BR443 default calculation values ■ If we use 'in-use' factors then surely the u-value is wrong ■ Produce a range of performance ratings, not single figures ■ If green deal and SAP both use 'in use' factors should 'new build' do the same? eg Correction factors - default value to use for all wall ties ■ Any tool for design / compliance needs to be more reflective of actual performance ■ Lack of verified information for design simulations re. performance of elements/services ■ Boiler malfunctions claim a 'performance of say 91% but 'in use' perform at 85% - is this factored into SAP? ■ Window u-value calc based on standardised panel, not actual size ■ True therefore calculate each ■ Requires modification and change to SAP algorithm to do properly. G-Values? ■ Are standard calculation methods giving real life info? ■ U-values are dynamic and therefore affects this ■ Evaluation process in design needs to more sensitive to in-situ performance in energy and other areas ■ Timber fraction not properly included in calculation. Is this methodology or as-built not meeting designed ■ Ventilation assumptions ■ Is design input products the same as what was built? ■ Testing of materials combinations used on site ■ Material u-values - lab tested not in-situ ■ Workmanship 'constant?' ■ Protocols for using product data ■ Are there adequate protocols? Basis ■ There is a lot of tested materials data and tests already available - more than most other SAP inputs

Theme	Issues
	■ Ultra low water use fittings are not accounted for ■ Need for evidence based tolerance in models? ■ Need to understand and apply tolerance to materials inputs and to specific constructions - a simplistic tool will never match as built, tolerance needed. Too many assumptions which are based further assumptions.
Issues for other WGs	■ Validity of Inputs ■ Design calculations can be done by unqualified assessors - why is the qualification cost so high? Why is the value of design being 'dumbed down'? ■ How do we measure built CO2? ■ Quality of what good is in SAP? Who polices this? ■ How do we improve the link between B. Control and SAP assessor? Builder and Architect? ■ The role of the B. Inspector is to confirm, not calculate ■ Checking by 3rd party of thermal details to see if correct. Checking of competency of thermal models. How do we check thermal bridges PSI values modelled are as good/bad as modelling software. Competency of people doing the u-value calculation? ■ Level playing field between SAP EPC schemes and assessors crucial - to avoid commercial driven SAP assumptions by assessors. ■ Key drivers for consistent data collections; SAP conventions, Scheme moderations, SORs for EPC schemes ■ How do we test as built performance ■ How accurate is an as built test? ■ Value/commercial awareness of SAP inputs by assessors ■ SAP assessors are undervalued and not consulted early enough in the process.

WG3a - Materials & Products

Theme	Issues
Product Design - Detailing/Installing	■ Impossible details used on site (only work in CAD) ■ Services need to be considered in full at the design stage ■ Accredited installer scheme for specialist products with sign off ■ Cavity Width variation - insulation expands or compressed ■ Installation of services may not allow maintenance ■ Installation control if critical issue eg. weather, other trade likely to damage ■ Material manufacturers do not consider the installer ■ We know what to do but not when to use it eg. solar shading ■ Industry installation methods are not always common therefore variation comes in ■ Competency of the supply chain need to reviewed ■ Design solutions should reflect practical sizing of associated insulation - easily available and potentially cheaper
Information and Skills	■ Is there a use of BIM or visual aid that could help? ■ Product induction training mobile apps? ■ Describe installation in pictures not words (foreign trades) ■ Are construction details too complex at junctions for work force? ■ Awareness of thermal issues by site staff eg. air tightness

Theme	Issues
	■ Skills and knowledge, training and motivation ■ Inspection checklist for situation and installation eg. briefing notes on what to look for or certification needed
Labelling	■ Product labelling (insulation) easy identification, grades, types, thickness ■ Make correct substitution of products easier ■ Lack of good visual labelling of materials (to help with correct use) ■ Wall ties are a good example
CE Marking	■ U-values not easy to communicate to allow accurate heat loss ■ Values are not verified - especially if no standard ■ Improve verification of performance data of materials / products and components ■ Decl. Values based on 90%ile values. IS this right? eg. 95% used for structural props ■ CE marking should help here; throughout the supply chain ■ In some euro codes materials are declared as mean. Overall performance of composite is characteristic
In-situ System vs Lab Products	■ Products are lab tested but system can be on site ■ Do manufacturers take into account the impact of weather? Sensitivity analysis needed to give some idea of this effect ■ Materials / products must be based on in-situ performance ■ We do not live in a laboratory ■ Lack of drivers for product innovation focused on in-situ performance ■ EN test methods may not reflect in-use conditions well enough ■ Current driver for optimised lab performance, not in-situ performance ■ Do designers use reference values rather than design? ■ Need for standards - in-situ/co-heating test ■ Proprietary tests are not comparable ■ Lack of system performance values rather than individual performance. ■ Materials should be tested as part of a system ■ On site product performance inferior to factory test results ■ Heat loss calculations are not accurate - system sizing? ■ Performance claims not reflecting build practice. Sensitivity of materials to poor construction practice.
Dynamic Reality vs SAPs Assumptions	■ Should lifetime performance of materials be considered? Aging is used for some insulants ■ Lack of understanding of influence of dynamic effects eg. Wind ■ Dynamic conditions in service vs. Steady state testing (wind, temp change) ■ Calibration of thermal design models by real life tests ■ Agreed - if wind wash is an issue, do we attribute this to product. Should it be in design or designed out? ■ Choosing appropriate materials/structure for site weather conditions ■ Identification of materials performance is difficult ■ Accounting for weather in a real life thermal test
BR443	■ Use of defaults for ease - lack of understanding of effect ■ Who checks calculations?

Theme	Issues
	■ BR443 needs updating and reviewing ■ Declared values vs in situ performance? ■ Thermal looping and bypass ■ Poor levels on compliance with BR443 eg point cold bridging for fixing of external insulation ■ Simplified design - we don't use EPBD stds that account for variation in performance ■ Appropriate methodology used for planar u-value calculations? U-value calculations are overly optimistic and no reason to change ■ Off-site elements need accurate u-value calculations ■ Set default values much higher level
Issues for other WGs	■ Product substitution is rife - "equivalent" is not the same ■ Not building what the design is - RD experience = 12% variance ■ Lack of understanding of product performance by specifier (architect) ■ Huge commercial pressure from housebuilder for over optimistic SAP and product performance ■ Incorrect material specification by architect ■ WG2b & WG5a - design assumptions not reflecting practice eg nonexistent solar shading in SAP

WG3b - Procurement

Theme	Issues
Cost / Value	■ Silo Mentality ■ Value engineering ■ Surveyor supply change competency ■ EU procurement ruled ■ Tender process weighted towards cost not always quality ■ Is V/E (or valve) lowest cost ■ Price focused decisions ■ Understanding the added value of supplier approved installers ■ Cost will generally override performance optimisation ■ Rewards and recognition not based on delivered performance
Change control	■ Supply chain collaboration - short term approach prevails ■ Cut and paste - spec/details ■ Lack of 'change control' process ■ Pace of change ■ Knock on effect on following packages not properly thought through
Product substitution	■ Lack of understanding of the wider implication of changes on performance of particular systems ■ Understanding of performance claims from the supply chain. Need for procurement to apply rigorous checking ■ Product substitution - what is 'equivalent'? ■ Product satisfaction usually means 'cheaper/lower quality' ■ Limited credit given to verified data ■ S/C can provide alternative product for cheaper ■ Lack of accountability of procurement to hit performance levels

Theme	Issues
	■ QS understanding of performance goals ■ Miss-sold goods / over claimed
Subcontractor issues	■ Lack of site supervision / understanding of design and S/L packages ■ Detailed design left to sub contractors ■ Too much resilience on sub-contractor to co-ordinate own work and quality process
Tender Documentation	■ MHVR - need training. Write in spec ■ Lack of understanding of critical component specification issues (product performance vs cost) ■ Are trade specs adequate to drive performance ■ Is correct trade spec being used? ■ Consequential impacts?
Skills / Training	■ Better links between industry and colleges ■ Sub-contractor accreditation schemes ■ Knowledge provided by supply chain ■ Skills and knowledge, training and motivation ■ Lack of on-site training ■ Client lack of knowledge ■ Limited skills of sub contractors ■ Some depend on supplier for information
Continuity / Communication	■ Cost/Time pressure ■ Poor continuity in procurement ■ Procurement often commences before design concept due to time constraint ■ Client brief/wishes lost in process ■ Client / PQS / Contractor / Sub contractor ■ Communicate key requirements through tender process
Themes for other WGs	■ Procurement of architects/designers/consultants not in this group - WG3b? Should be in; WG2a or WG0. May expand to other areas in later WG life ■ SAP is tick box. SAP cheapest is worst thought out solution. ■ Unrealistic demands from planners ■ Added premium / value given by valuers for better performance. Estate agents and solicitors having some understanding of better standards ■ Poor design can add cost, then procurement look for saving to off set it ■ External influences impacts on effective supply chain solutions

WG4 - Construction

Theme	Issues
Products	■ Product Labelling ■ Different products or details used are not picked up ■ Product substitution by site managers ■ Contractor changes product and tells no one ■ Effective labelling. Merchant --- Contractor --- Site delivery --- Install

Theme	Issues
	■ Product declarations and claims
Work Planning	■ Time pressure on delivery ■ Lack of time / funding to undertake proper commissioning ■ Working planning. Key ---- Inspection points --- NHBC / LABC ■ Logistic planning needs to be better focused to ensure effective work sequences ■ Tied in with the restraints final 6-8 weeks
Trade Dependencies	■ Clash Points with on-site rather than designed out ■ Services clash; Insulation / Ducts
Weather	■ Wind driven rain!! Is there a minimum cavity wall?
Renewable building services	■ Renewables ■ Unintended consequences - poor design of M and E to achieve improved SAP performance
Detailing	■ Issues with continuity of insulation ■ ACDs ■ Installation guidance A/T, T/B, insulation ■ Replicability ■ Wall build up resulting in u-value ■ Trade packs - identify responsibilities and manage synergy
Tolerances	■ Masonry trades and timber frame interaction - old but still an issue ■ Prefabrication ■ Lack of fit due to setting-out errors is. GAPS ■ Lack of coordination between foundations/super structure (design stage?)
Inspection and Commissioning	■ Insulation inspection - LABC / NHBC , self audit ■ Sample test junction to details and PSI - visual inspection similar to RSD ■ Photographs ■ Accuracy of test regime ■ Lack of independent checks - building control / NHBC? ■ Building control - only common in SME and large developers - must have more power ■ Ventilation - commissioning ductwork design
Skills and knowledge	■ Lack of understanding of the wider implications of changes on performance of particular systems ■ Skills and knowledge, training and motivation ■ Lack of understanding of impact of actions on performance ■ Air testing - trade knowledge is poor ■ Knowing enough about other trades to understand how they could contribute to good performance - to avoid inadvertent damage to overall approach ■ Trade pre start meetings
Competency	■ Competency schemes - insulation / ventilation ■ Ventilation volume testing must achieve design target with consequences if not ■ Education of teams to know why design is as it is, 'buy in' ■ 'Tool box talks' to key trades

Theme	Issues
	■ Operatives training - tool box / lunch and learn
New Entrants	■ New entrants to industry ■ Lack of trades - bricklayers ■ Language barriers ? (cultural and international)
SAP design change	■ Known heat loss points - confidence factors needed in SAP ■ SAP. If you add a window or change materials - SAP is not revisited
Cultures / Behaviour	■ Ownership of individual trades ■ Assign responsibility ■ Behaviours, KPIs ---- Culture - not reward and recognition ■ Workmanship contracts
QA and Supervision	■ Designs of details not followed as 'I have always done it this way!!' - Education ■ Lack of quality control ■ Skills and basic understanding - trade integration ■ Supervision doesn't have to mean paperwork - must have leader ■ Lack of supervision ■ Supervision of trades on site and quality of installation/build
Feedback / Continual Improvement	■ Feedback loop - refinement process ■ Communication needed back up line from construction ■ Feedback on detail and products - what's not working? ■ Inspection / checking of work back to the design criteria
Builder profile	■ Think about SME's - must not introduce barriers to entry

WG5a - Verification

CURRENTLY MASS SCALE:

Concept & Planning

What	Who	How
CSH	CSH Assessor	CSH Certification

Design

What	Who	How
Establishing what has been done at design stage; - fabric, heating etc - architect plans, details	SAP Assessor	Talking/Emailing to the developer/architect
Thermal bridge design	Accredited software users	Certification by provider
Insulation	Builder, designer, building control	Spec measured against standards
Energy using systems	Builder, designer, building control	Spec measured against SAP standards
	No quality assurance of assessors at design stage	

Materials, Products, Systems

What	Who	How
Does it work as advised	Testing House	Independent results (but are they for real?) Fit for purpose
Manufacturers published performance data	Manufacturers	BBA, etc
Production and Control	Accreditation bodies	Factory process control
FSC, PEFC Accreditation (wood)	Site manager / architect	

Construction

What	Who	How
Fabric	Site QA/BC C4SH assessor	Visual inspection
Energy Systems	Site QA/BC C4SH assessor	Visual and comparative inspection

Commissioning

What	Who	How
Pressure tests and smoke tests	Competent persons	On site sample test - BC notice
Boiler / Heating system & controls?	? For system and controls apart from boiler Domestic: qualified installer (contractor) Non-dom: Manager of development / engineer	Gas safe boiler heats water verifies works but not checking system is doing the right thing Heat pumps - black art
Energy systems and lighting	Installer CPS	BC motive - self certification
SAP Assessor	Establishing changes from design stage inc. Documentary evidence for as built	Written confirmation by email/letter etc from developer
As-built SAP/EPC	Builder and SAP assessor	Modelling results to BC/Planner
Users manual	Developer	Passed onto BC

CURRENTLY LOWER VOLUME:

Concept & Planning

What	Who	How
Merton Rule	The Planners (information officer)	Test against policy
LA (general) Local Energy Policy		The Ealing Condition
Sustainable Development (off grid) in Wales	Enforcement officer check	Permission withdrawn in conditions breaches

Design

What	Who	How
Passivhaus design	Accredited assessor plus designer.	PHI standards. All 4 processes by perhaps 4-5 different groups above integrated holistically in this single alternative

Materials, Products, Systems

What	Who	How
Passivhaus House installation product verification v. Rigorous, designed by building physicists)		

Procurement

What	Who	How
Correct spec?	Buyer	Quality of information / spec from designer

Construction

What	Who	How
Verification of as-built report inc. Photos on installation as part of PassivHaus installation certificate		
Window installation for air tightness. Visual verification needed during construction	Site manager, carpenters, apprentices, (architect?)	Training inspection components, supply chain advice and support
Window installation for ventilation	?	Check against design intent

Commissioning

What	Who	How
All above verification of commissioning drawn together in passive house certification	Cert. Docs	Architect engineer commissioning eng PHI certifier
Zero Carbon Homes	ZCH	?
Fabric Integrity	Occasionally	Infra-Red photos
Smart Home Energy Management	Energy Supplier / Broker	Visibility of performance in home display / home banking plug in
Ventilation air flow rate / fan power	?	Builder / installer BC notice

Overarching gaps

- Verifying that SAP assessors are meeting quality standards (EPC accreditation schemes)
- Verifying that EPC accreditation scheme are meeting quality standards. Processes exist but need strengthening
- Establishing clear conventions for SAP and Part L compliance assessment and ensuring applied consistency (process exists but weak)
- As Built SAP rarely requested by BC
- Party Wall sealing or sealing and filling. Who verifies that deserves u=0.0 or 0.2 in SAP assessment?
- Verification of boilers / heating. Manufacturers declared efficiency
- Specification or similar!! Verifying appropriateness of substitutions.
- Soft landings approach with performance champion(s)
- Functionality and usability of controls. Control ergonomics and user guidance
- Testing for kit done in lab not in real life situation
- Items often tested as components - not in systems
- No standards test for verifying as built performance
- Combinations of materials not tested
- On site testing of M&E systems (rather than eg just checking boiler heats water
- Window installation for training verification and installation verification
- Verification of strategy for air tightness (design, then construction)
- Need to verify each key construction stage by air testing; fabric, M and E, completion
- Heat recovery ventilation / training verification / installation verification / commissioning verification
- Lack of quality incentives - eg. Minergie in Switzerland - voluntary advanced standard that is believed and adds value
- Thorough design methodology needed to verify design objectives likely to be met in reality - PHPP provides this
- SAP was not developed to be a design tool
- PHPP as alternative to CSH at design and planning - more accurate
- BC - not a site QA process
- Rigorous, thorough report explaining reasons for ventilation test results, pressure performance, expectations, user guides

- Lack of architects in construction quality verification and clerks of works
- Statutory notifications to building control don't include insulation

WG5b - Testing

Concept & Planning

What	Who	How
Resilience	Master planners	BRE framework
Best practice layout	Master planners	Urban design compendium
Sustainability	Planners	NPPF
Environmental conditions	Meteorologists	Weather stations

Design

What	Who	How
SAP/Part L compliance	SAP assessor	SAP tool / software
Overheating	Building services engineers? Consultants?	Dynamic modelling / CIBSE Benchmark
Sustainability	Design team	CSH
Energy performance	Design team	PassivHaus
Water use	Design team	Water calculator
Heating design	Building services engineer	Best practice engineer
Sense check	Design team	Visual
U-value calculations	SAP assessor Other consultant	Software
Condensation risk (for thermal bridging)	Consultant supplier Insulation supplier	Glazier
Daylight factor (for heat loss)	Consultants / architects / lighting supplier / window supplier	Software

Manufacturing

What	Who	How
Conductivity	BBA/NPL	Hot box
Thermal conductivity of insulation	UKAS accredited test body Manufacturer	ISO standards - heat from meter
Life cycle impacts	BRE	Ecopoints
Life span	Manufacturers	Weathering test
Air permeability	UKAS labs	EN standards
Boiler efficiency	Sedbuk	Heat output
Radiator output	Manufacturer	Heat output
Renewables	B and E / Appendix Q	Standard condition - output
Lighting efficient	Manufacturer? Test Houses	Output measuring LUX Measurement
Dynamic U-value; wind	BBA/NPL	ISO 8990 - consideration on parameters
U-value measurement - steady state		
Heat loss phenomenon's ie air looping	Researchers	Specific experiments
Mechanic junctions - MVHR Specific fan power % heat recovery	SAP Q - BRE	Lab tests to BSEN 13141? and refinements for Part F
Performance underling driving rain	BBA and others	Standards and future work

Construction

What	Who	How
Blower door Ach @ 50pm	Contract testing; research/academic	Standardised method variation (risk)
Air permeability	BINDT/ATTMA organisations	ATTMA or EN Standard
Smoke identification of air leakage paths	Researcher	During blower door
Thermal imaging	Researchers trained therm-architects	Cameras - restrictions on conditions
Thermal imaging; linked to U-value mass	BSRIA / BRE / Other	Thermal camera (& agreed methodology standards)
Co-heating test	Researchers /ACA Consultants	Protocol variations (risk)
Heat flux	Researchers /ACA Consultants	ISO standard - possible monitor match
Dynamic testing	Researching consultancy	?
Forensic Investigation Temporary sensors Air speed in cavities	Researchers / Academics	Experience
Tracer gas	Researchers	No given protocols
Building protocol Destructive testing	Building Surveyor / engineer	Break into walls and sample construction
Sound transmission (possible proxy for leaks?)	Specialist	EQPT on site

Commissioning

What	Who	How
Ventilation - air flow rate against design MEV/MVHR	Mechanical and electrical	Air flow meter - calibration issues
Heating/Cooling systems; boilers, air-con	Mechanical and electrical, plumbers	In-line with design guidelines
Indoor air quality; relative humidity, indoor air quality, temp	Env. Assessors and consultants	In line with standards and methodologies
Energy consumption of services (use data to commission services)	Design consultants	Energy meters
Power generation eg. PV, solar thermal, wind, ASHP/ GSHP	Mechanical and electrical	Metrology
CSH/BREEAM Post construction	Assessor	Other measurements, consultants, contractor

Overarching gaps

- Thermal insulation vs Test Evidence (windows/doors) LINK Energy ratings, inc solar heat gain
- Admittance - comfort? , build main systems
- Operative temp as control
- Factors that influence measurements - statistics are significant LINK Extrapolation of results
- Consistency between labs - UKAS? BSI/CEN/ISO - Tech standards? Accreditation
- Impacts of climate change uncertainties
- LINK between all stages (use of soft landings) - between all stages not just handover to final client occupant - 'WGO Process'
- Building information monitoring and modelling
- Usability testing and control interfaces for products operated by end user - main product testing and focus groups - scope?
- Lack of industry appetite for existing information
- Unintended (neg?) consequences of testing (co-heat?) - programme delays

WG5c - Construction Joint Details

Existing ACD Issues	
Expanding scope or not	■ SAP/Builders find multiple junctions burdensome ■ Junction variants. Uncommon junctions – diminishing returns ■ Not enough junctions considered ■ Number of junction types currently in SAP
Is 'common' possible?	■ One fits all! London vs Suburbs ■ What is common build practice ■ Consistency? To set a pattern book
Current unintended negative consequences	■ Details already modelled by 3rd parties (how to credit) ■ ACDs desensitised. Detailed calcs to be done. SAP defaults.
Future innovations need	■ ECDs concept no longer valid ■ Could we 'steal' more from 'prototype' ACDs which may already have been designed and modelled ■ Could new ACDs be invented in collaboration with component manufacturers more – eg lintel makers
Limitations / Problems	■ ACD construction details not relevant to 2013/16 likely practice ■ Need to review: does it work? Are they current? ■ Constructive details show real large variability for generic details ■ ACDs valid only over/around 0.3 wall u-value ■ Constructive details highlight many errors which set to prevail? Each detail too simple to be generic ■ U-value and material ranges outdated ■ ACDs – out of date for current urban housing design trends ■ PSI values do not reflect future fabric standards
Tick box approach	■ ACD site/SAP 'tick the box' too tempting even if no correspondence ■ Is there really such a thing as a default/ACD house (range of details)
Information flow and site issues	■ Difficult to inspect (construction timing) ■ Substitution of materials ■ Design assumed – not made for execution

Who	**What are their needs?**
Architect	■ Full understanding of the brief with good guidance and setting the standards ■ Clear information on details and PSI values. Consistency approach. ■ A richer new pattern book of ACDs which are easily downloadable in CAD and REVIT format ■ Explanation - education for architects on the 'Son of ACDs' which is graphic
SAP Assessor	■ Comfort Zone - 'Happy with status quo' ■ Info flow is key; designer/builder/BC ■ As-design list of details to be used ■ As-built confirm all details used ■ Clear info on details and values - consistent approach ■ Adequate design information

Who	What are their needs?
	■ Full understanding of the impact of the boxes they tick. To not be able to tick boxes? ■ All SAPs should have detailed HTB calculations ■ OCDEA certification - ability to verify assumptions (PSI source of data) ■ How check late detail change
Builder	■ Performance Curve (80/20 rule) ■ Clear set of principles for modelling ■ Key details rather than all ■ Generic simple details ■ Ability for all to be used to obtain details easily or get modelled ■ Generic details must represent actual construction - builder LED ■ Keeping the paperwork simple - avoiding tick boxes!! ■ Understandable regulatory requirements (LINK to BC)
Building Control	■ Reduce Complexity? ■ BS seem very disengaged from the whole process ■ Understandable regulatory requirements (across industry) - LINK to Small Builders ■ Training ■ Site check lists required mandatory scheme ■ Funding?

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