ZERO CARBON HUB

COST EFFICIENCY GUIDE

A step-by-step guide for SME housebuilders on building energy efficient homes cost effectively

FEDERATION OF MASTER BUILDERS Est. 1941 fmb.org.uk

NHBC

citb

LABC

HBF HOME BUILDERS FEDERATION

sweett

CONTACTS

Further copies of this guide are available as a PDF download from www.zerocarbonhub.org

Or contact us

Zero Carbon Hub
The Zero Carbon Hub closed for business on 31 March 2016, but information will remain accessible on the website.

Sweett Group
Sweett Group is an independent business provider of professional services for the construction and management of building and infrastructure projects. As well as cost and project management, Sweett Group provides a wide range of specialist and advisory services to help our clients deliver better projects and business decisions.

T: 020 7061 9000

www.sweettgroup.com

ACKNOWLEDGEMENTS

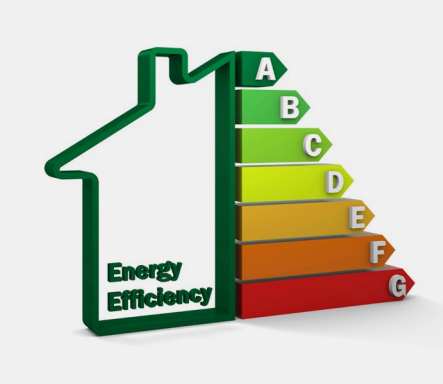
The Zero Carbon Hub is very grateful to the following contributors/ organisations for their involvement in developing this Guide.

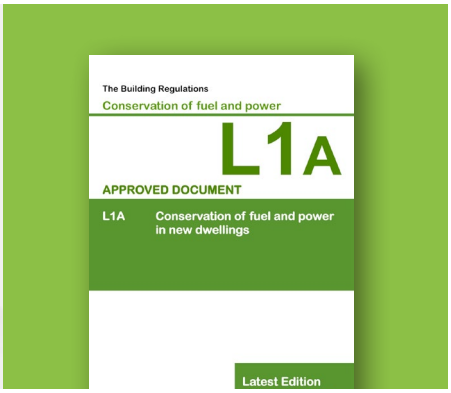
Author
Sweett Group

Project Advisors
Rob Pannell & Tessa Hurstwyn, Zero Carbon Hub

Graphic Design and Illustration
Richard Hudson, www.richardhudson.me

INTRODUCTION





New homes have to achieve high standards of energy efficiency, with the latest revisions to Building Regulations further tightening standards (Part L1A 2013 in England; Part L1A 2014 in Wales; Section 6 2015 in Scotland). A well-built, energy efficient home can provide significant comfort and cost saving benefits to home buyers and those organisations providing tenure and shared ownership. It is also a major factor in reducing fuel poverty.

This guide will help SME builders and developers cost effectively design and build highly efficient homes that meet or exceed minimum standards and deliver real savings in practice for occupants. It covers each stage of the development process and identifies some of the key opportunities to improve performance at low cost while highlighting some of the risks of poorly conceived or executed approaches.

This Guide is one of a series of good practice guides that are aimed at addressing the performance gap and improving the design, procurement and construction quality of new homes. All publications in the series are listed on page 6 of this Guide and are available from the Zero Carbon Hub website.

HOW TO USE THIS HANDBOOK

The Guide begins by highlighting areas of cost risk when building a low energy home. It goes on to summarise the recommended actions across six stages of the house building process. Following the summary, further information is provided on each stage with 'keys to success' and 'pitfalls to avoid'.

PLAN | DESIGN CONCEPT | DESIGN DETAIL | DESIGN SPECIFICATION | BUILD | HANDOVER

Within each stage, recommendations cover:

PURCHASING
Sub contract and Professional Services
Materials
Labour

MANAGEMENT
Programme
Personnel
Design
Construction
Overheads

THE BUILDING
The home's design, specification and construction.

WHAT IS A LOW ENERGY HOUSE?

A low energy house is one that requires only a small amount of energy to run. This is achieved through the use of specific design features, technologies and products in its construction.

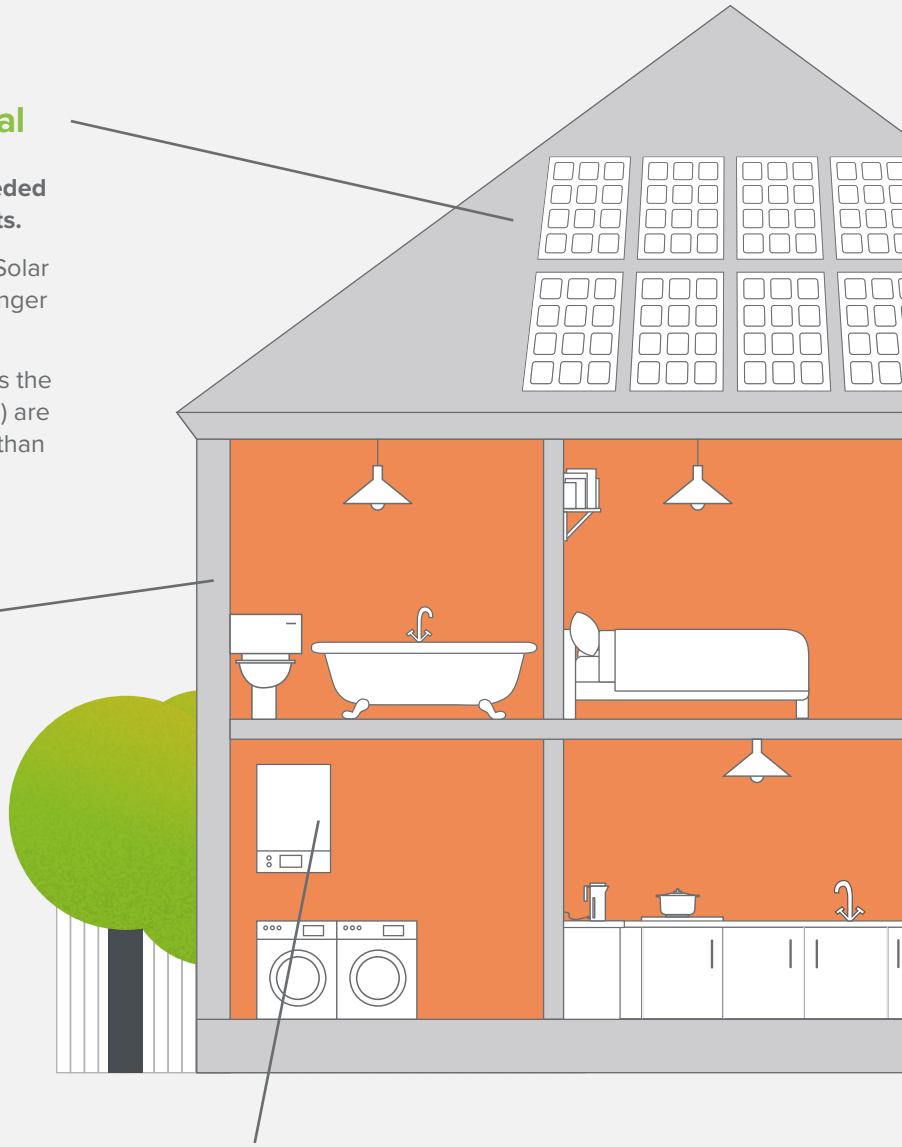
There are many things to think about when constructing a low energy house, which are highlighted here as a summary – and if you want to do this at an acceptable cost in your business, these areas become even more important and need to be thought about early in the development process.

Photovoltaics (PV) and Solar Thermal

Low and Zero Carbon technologies may well be needed in a low energy home – but be aware of hidden costs.

For example, roof mounted renewables (e.g. PV and Solar Thermal systems) will require additional budget for longer scaffold hire and overhead costs.

It is more cost effective to install a larger area of PV as the installation and non-panel costs (wiring, inverters, etc.) are similar as they are for smaller systems. Installing less than four panels is normally not cost effective.



Wall insulation

The approach to wall insulation can be a major cost for a low energy home.

Different insulation types vary in cost and performance:

- Mineral wool is cheaper and is often the choice for thicker walls compared to rigid board. This increases foundation sizes and sundry costs such as cavity trays, closers, lintels and wall ties. Mineral wool is available in 'batts' or 'slabs' or can take the form of ‘blown’ insulation.
- Rigid insulation takes longer to cut to fit than other insulations; and therefore increases labour costs. However walls may be less thick and more cost effective overall.

The best option will depend on your time and the skills of your contractor.

A simple building envelope will be easier to insulate well, without ‘cold spots’.

Heating

The source of space heating is a major cost consideration.

A very efficient gas boiler together with effective zone controls can make a big contribution to cost effective compliance with building regulations in a low energy home.

Consider heat recovery systems at this stage to save ‘total costs’ of the overall project.

Orientation

Orientation of the home can have a big impact on the effectiveness of certain solutions.

The quantity (and therefore cost) of renewable energy technologies such as Photovoltaics required to meet calculation targets is affected by building orientation.

Orientation and area of glazing should also be considered as this influences how much passive solar gain enters the home and also affects whether the home might overheat in summer.

Air tightness and ventilation

Improving airtightness will save energy at low cost.

An air tightness value of 5 $m^3/m^2/hr$ is a good target, but below 3 $m^3/m^2/hr$ mechanical ventilation will need to be specified; this will add to the construction costs and have design implications.

A low energy home can be achieved without mechanical ventilation, but the highest standards (e.g. Passivhaus) require these systems together with a very airtight fabric.

Be aware that ensuring a very airtight fabric requires additional labour resource and accuracy and may affect costs.

Thermal Bridges

Reducing thermal bridging is really important in a low energy home. If thermal bridging is not addressed then additional costs will be incurred.

Make sure that your designer has the skills to create effective and buildable details that have low thermal bridging; otherwise you will need to install more insulation or renewables to compensate.

Libaries of generic details are available to the designer and may be appropriate – these will save time and money.

Reducing thermal bridging will be easier and less expensive for simple home shapes, as the number and complexity of details is reduced.

In terraces, pay particular attention to stepped rooflines and staggered frontages.

Be aware that if bespoke details need to be modelled to calculate the thermal bridging value (to enter into SAP), this can be an expensive exercise.

PLAN

Key message for cost efficiency

Work with an experienced team that have the necessary time, experience and skills to develop a cost effective approach that meets your energy / carbon target.

- Work with a team with the necessary experience, skills and knowledge of low energy construction. This will prove cost effective over the duration of the project although may feel expensive initially.
- Engage with experienced SAP / energy professionals including asking for additional services on how to optimise your specification. Again this may feel like an unnecessary cost but should prove to be very worthwhile particularly when building to a new standard for the first few times.
- Make contact with your planning officer early to establish any project requirements or constraints. Building these requirements into your approach from the beginning will be much more cost effective than trying to incorporate them into your design at a later date.
- Develop a design and construction strategy that addresses the site aspect, dwelling orientation, your energy target and the skills of your project team.
- If you are building for a client, they may not be familiar with low energy design and construction and may need guidance on some aspects where costs are incurred.
- Study previous projects, particularly if unexpected additional costs were incurred, and learn the lessons.

DESIGN CONCEPT

Key message for cost efficiency

Engage an experienced energy specialist and use their advice to help optimise the specification. Keep the design simple to reduce cost.

- Get advice to identify the best combination of solutions for:
  - Form & orientation
  - Airtightness
  - Continuity of insulation
  - Thermal bridging
  - Low energy services and renewables

  Ask for the advice of an experienced energy specialist as the most cost effective solution will vary and costs and performance can change rapidly.
- Keep building form, mechanical & electrical systems, and any low and zero carbon technologies, as simple as possible. Complexity will cost money and in most cases it will be more cost effective to focus on using one strategy fully rather than combining various approaches, particularly when utilising low and zero carbon technologies.
- Check that design decisions are practical and can be built well by your site team. Don't ask them to work with lots of new technologies or construction details unless you are confident they can do this effectively.
- Identify the key design characteristics that are to be prioritised in the detailed design. E.g. to deliver thermal bridging or air tightness targets.
- Produce a construction programme early and update it regularly. This will control overhead costs.

DESIGN DETAIL

Key message for cost efficiency

Co-ordinate the design carefully and check that it can be delivered in reality. Redesigning when on site adds time and cost while reducing quality. Ensure that all services can be easily maintained and accessed.

- Check that your design assumptions can be delivered in reality, e.g. can you install insulation into every part of the external envelope easily and effectively? Difficult to access areas will take longer to complete or not be finished correctly and may result in additional costs in construction or in customer complaints and expensive return visits after handover.
- Co-ordinate the design carefully to ensure ducting or other services can be routed smoothly and efficiently, making them quicker and more cost effective to install and less likely to cause problems in use.
- Ensure key building services are in locations that can be accessed for maintenance. This will reduce maintenance costs and return visits in the future.
- Check the implications of any design or specification changes on energy consumption and SAP rating to avoid the need for costly remedies to achieve the necessary performance standard.
- Start to think about what products and materials will be needed during the build phase and investigate the best suppliers for key technologies. This will increase efficiency on site and should reduce cost.

DESIGN
SPECIFICATION

Key message for cost efficiency
Produce a detailed specification and communicate this clearly to reduce the risk of costly errors in procurement or construction. Use trusted sub-contractors to ensure quality.

- Produce a detailed specification for the building fabric and services. This will reduce the chance that items will be bought or installed incorrectly. This may increase design time but will save time and cost during the build and should help ensure completed dwelling performs as intended.
- Appoint a vigilant and conscientious site manager / clerk-of-works who is aware of quality control requirements. Ensuring that the right products are installed correctly will be much less expensive than having to make changes following a failed building control inspection.
- Appoint sub-contractors who have the necessary skills and identify any training requirements. This will increase the speed of installation, improve the quality of the build and reduce cost in the long term.
- Confirm with the site team that all the technical details are clear and buildable.
- Finalise the programme and sequencing and communicate with the project team.

BUILD

Key message for cost efficiency
Focus heavily on quality and use a quality management checklist. Be aware of the risks from substituting products to try and save money as it could cost much more later in the construction process if energy performance is reduced.

- Use a quality management checklist that covers:
  - Thermal bridging
  - Airtightness
  - Continuity of insulation
  - Correct specification
  - Services installation
  - Commissioning

  This will demonstrate to the supply chain what will be checked to encourage high quality construction.
- Reduce the risk of misunderstandings by reiterating key design and performance requirements throughout the construction phase.
- Use the site manager to monitor quality control and provide feedback on potential issues to the design team. Communicate with them regularly to address issues as soon as possible.
- Stick to specified materials and components. Changing products can impact performance and the As Built SAP score. If changes are required these should be signed off by the designer/ SAP Assessor with the energy performance implications explicitly stated.

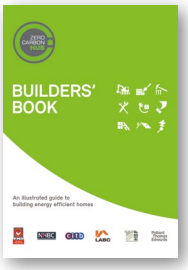
HANDOVER

Key message for cost efficiency
Reduce the risk of costly return visits by commissioning thoroughly and explaining to the client or home buyer how the services work and what they need to do to get the most from them.

- Commission all of the building services carefully. This will reduce return visits and improve performance and customer satisfaction.
- Provide suitably simple and clear guidance and appropriate training for the client or home buyer to ensure they know how to use all the building services. This will improve understanding and reduce the need for return visits.

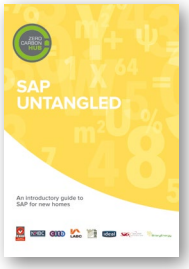
DESIGN AND CONSTRUCTION GUIDANCE

The Zero Carbon Hub has published the following good practice guides aimed at addressing the performance gap and improving the design, procurement and construction quality of new homes. They are referred to in the following sections of this Guide and can be downloaded from the Zero Carbon Hub website www.zerocarbonhub.org/guidance.



Builders' Book

A good craftsmanship guide that highlights key construction details when building a new home, and good practice for delivering them. Covers traditional masonry construction only.



SAP Untangled

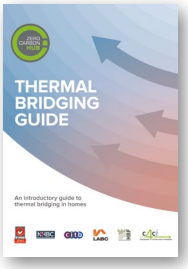
A basic introduction to the SAP assessment process and the information required by the assessor and Building Control in order to achieve compliance with certain aspects of Building Regulations Part L1A 2013 (England) and the successful production of an Energy Performance Certificate for the home.

Services Guide

Offers good practice guidance aimed at improving the standard of building services in new homes. Focused on the major problems around design and installation of services that affect comfort, indoor air quality and energy performance.

Designers Handbook

Advice on designing comfortable, low energy homes that perform as intended. To be published Summer 2016.



Thermal Bridging Guide

A simple guide to what thermal bridging is, the key construction details in new build housing where thermal bridging is particularly significant, examples of ways in which heat loss can be reduced by changes to the design and construction of these details, and the problem areas to avoid on site.

PLAN

KEYS TO SUCCESS

Early stage SAP analysis can improve efficiency

Appoint a well-qualified and experienced SAP Assessor - you are not saving money using a low cost Assessor who is not able to offer advice unless you are very sure your design is optimised! Ask the assessor for examples of how they have helped to refine design options.

Decide construction methods early

Deciding construction methods before starting concept design will avoid compromises later in the project. For example, sometimes where a home fails to deliver its energy efficiency performance a developer may choose to add a couple of photovoltaic panels to meet their energy target. This avoidable fix is expensive in both cost and time.

Request an enhanced SAP service

An experienced SAP Assessor / energy consultant provides expertise to help reduce costs by:

- Specifying the heating system in detail (avoiding worst case assumptions)
- Optimising the combination of air tightness, fabric (U-values and thermal bridging), and services

It is also best to procure both the Design Stage and As Built Stage SAP Calculations from the same Assessor - the continuity can help accuracy and might reduce costs.

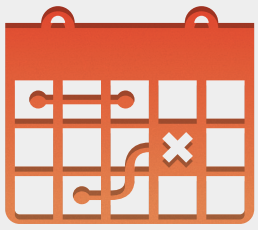
Put in place a programme from the start

Know what you're doing, and when, before starting on the design and build process. This will ensure the smooth running of the project, avoiding costly delays and oversights.

Work with trusted and experienced project teams

Where possible, develop and maintain an ongoing relationship with a consistent project team. Work together to develop knowledge by bringing lessons from previous projects to new ones. The skills and experience of your designers and site teams are critical to success in cost effectively delivering a low energy home. Check that your team have expertise in the following areas, and if there are gaps work with them to develop the necessary knowledge and experience.

- Form & orientation
- Airtightness
- Continuity of insulation
- Thermal bridging and modelling (BR497)
- Low energy services
- Low and Zero Carbon (LZC) technology



PITFALLS TO AVOID

Don't forget the planning department

Planning officers will be able to provide valuable information on local requirements and offer advice on how best to get designs through the planning stage.

DESIGN

KEYS TO SUCCESS

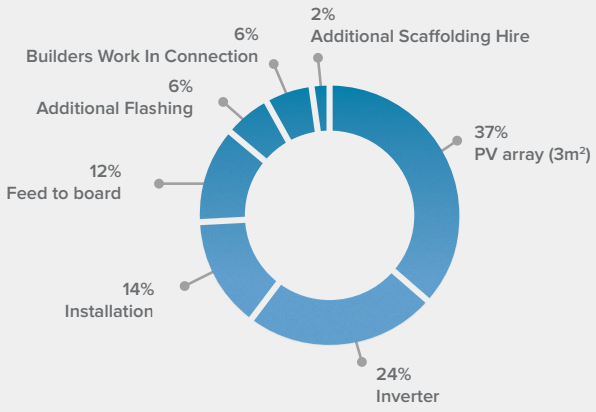
Compare the total costs of each option

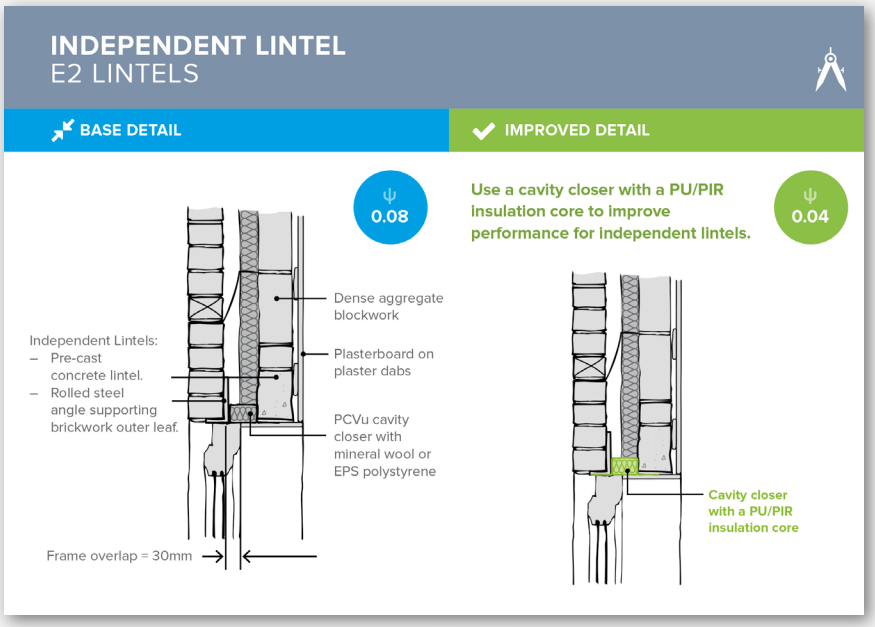
For example, installing PV will increase the duration of scaffold hire and will require additional wiring and electrical equipment. The cost of the PV panels themselves is only around a third of the total cost. Similarly, whole house mechanical ventilation with heat recovery (MVHR) systems will require extensive ductwork and will only lead to significant savings if you are able to deliver an air tight envelope. Failure to assess all the relevant costs when deciding on the solution will result in poor decisions and greater costs down the line.

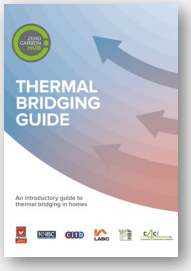
Tweak the specification to improve performance

A well-insulated home will not perform well without attention to thermal bridging (20-30% of total fabric heat loss can be through thermal bridging). Small specification changes can make a big difference. For example, using independent lintels or cavity closers with a PIR insulation can significantly reduce heat loss through thermal bridging, as can using low density/ aerated blockwork instead of dense blockwork.

The cost breakdown of installing PV panels







Taken from the Zero Carbon Hub's Thermal Bridging Guide

If you use PV, use it efficiently

It is far more cost effective to use PV in quantities of 1kWp or more. If you only use one or two panels the fixed costs such as scaffold, inverters, wiring and installation will be very high and the benefits to the household small. In this situation it is better to either further improve fabric performance and avoid using PV altogether or to use a significant quantity and gain the flexibility to reduce performance tolerances in other areas.

A simple and compact building envelope

A compact building form is inherently more energy efficient and will have less external wall area and fewer thermal bridges per square metre of living space.

Use realistic expectations in the SAP model

Do not leave yourself open to the risk of failing to achieve the design SAP assumptions in the finished home. Rework or compensating measures will be expensive and time consuming. For example, achieving high levels of air tightness is not easy if you are not familiar with the processes and products required. Set a realistic target and work up to higher levels of performance (with a suitable ventilation strategy), only once you know you can achieve them.

PITFALLS TO AVOID

Combining lots of new and complex building services

Many new technologies can deliver significant energy savings, but it is best not to mix too many systems in one home, particularly if you are not used to co-ordinating the design and installing those systems. Where possible, use an experienced professional and / or installer to check that the final design can be installed without clashes or other problems that will impact quality, cost and programme.

Installing chimneys without fires

Providing a chimney or flue increases heat loss in a home and, if no appliance is provided, SAP will make worst case assumptions about the future heating system, either a 20% efficient gas fire (if a gas tap is available) or a 37% efficient mineral fire (if no gas tap). If you want to include a fireplace, then a log burner with a sealed flue will perform best in SAP and should improve rather than diminish the home's energy rating.

Using the wrong specification information

Many products have numerous very similar performance standards, it is important that the correct data is used to inform the SAP model otherwise the final As Built certificate may be worse than expected, which may result in potentially costly remedies. For example, SAP needs the U-value for the whole window not the centre pane value. Similarly, SAP uses information on the seasonal efficiency of boilers in summer and in winter, so two boilers with the same average annual efficiency may perform differently in SAP.

Leaving weak spots in your insulation

Cold spots in a home, whether due to missing insulation or thermal bridges are even more noticeable in an otherwise well insulated home. If they give rise to damp or mould then there will be a need for rework, and your reputation may also be damaged.

For further information reference should be made to the Designers Handbook.

BUILD

KEYS TO SUCCESS

Use an experienced construction team

Ensure your installers are experienced / qualified in the technologies with which they are working. Train existing employers and trusted sub-contractors where required e.g. Heat Pumps should be installed by Microgeneration Certification Scheme (MCS) certified contractors.

Develop a quality control checklist

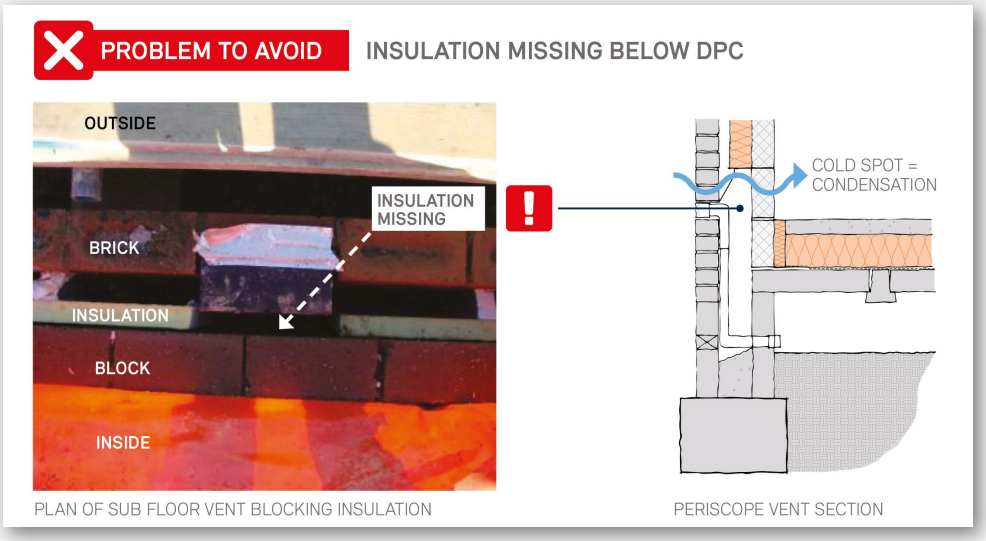
Develop a standardised checklist for quality control which covers the key areas. This should be signed off by the site manager. Use the Zero Carbon Hub's "Builders' book" to identify the top issues leading to poor performance (link on page 6).

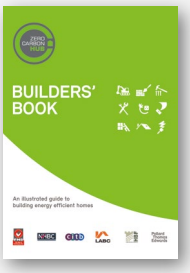
Focus on quality control

It is vitally important to make sure the quality of construction is of an excellent standard. Make sure the site manager is fully aware and trained on the required quality standards to meet low energy home requirements.

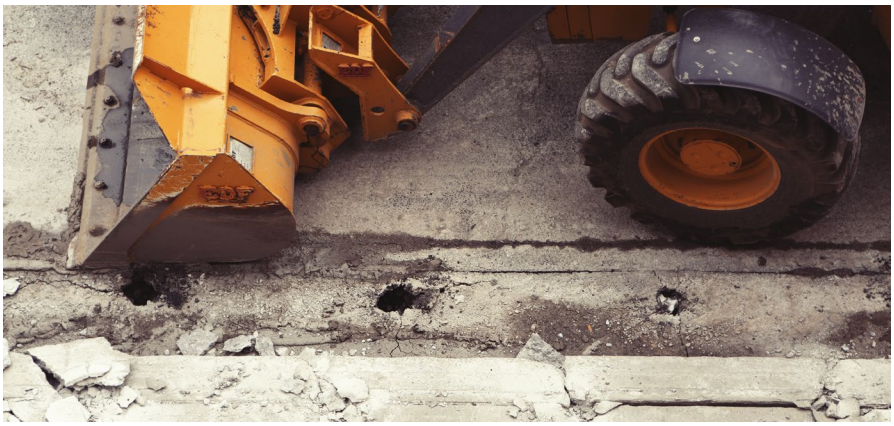
Fully commission all building services

Any mechanical and electrical services will require commissioning to operate effectively. It is important to identify requirements and allow time in the programme. Ensure all installers are suitable trained and aware of the requirements e.g. Domestic Ventilation should be certified by someone with BPEC Certification.





Taken from the Zero Carbon Hub's Builders' Book



Communicate with site team effectively

Communicate all the detailed assumptions in design stage clearly to site teams so that they don't have to undertake compensating works. For example, you don't want to have to deal with:

- Boiler substitutions
- Non-insulated pipework
- Missing fabric insulation because of difficulties in building to the design

PITFALLS TO AVOID

Don't assume that similar products will perform in the same way

The construction type, make and model of the construction materials and services will all perform differently and have different properties. Substituting products can impact the performance and affect the As Built SAP score. If a product change results in the performance standard being missed then you may need to replace the incorrect product or invest in expensive compensating measures that may affect the quality of the finished design as well as taking up additional time and money.

Don't stray from the specification unless you are sure of equivalent performance

Purchasing alternative materials to those specified can harm performance. If changes must be made, make sure they are like-for-like, taking into account all aspects, including energy performance characteristics.

PROBLEM TO AVOID

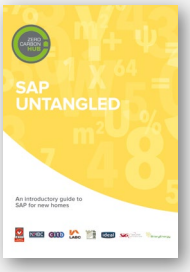
SUBSTITUTING THE BOILER ON SITE

Changing the boiler, without re-running the SAP calculation can cause issues with compliance, even if the overall SEDBUK figures are the same. This is particularly evident in combination boilers where the efficiency of hot water production can differ, meaning the DER could be affected.

Not installing full zonal controls, weather compensation or delayed start thermostat, when these have been assumed in the Design Stage calculation, will have a negative effect on the DER.

Swapping fuel types will have huge implications – e.g. installing an electric boiler where the Design Stage calculation was based on gas

Always check with the SAP assessor before changing the specification between Design Stage and As Built Stage, especially when substituting products.



Taken from the Zero Carbon Hub's SAP Untangled

HANDOVER

KEYS TO SUCCESS

Make maintenance easy

Make sure systems can be accessed for maintenance otherwise performance will degrade leading to potential reputational impacts and return visit costs.

Commissioning

An effective commissioning programme is vital to reduce the need for costly return visits. Building services need to be fine-tuned following handover to ensure they are operating in line with the design intent.

Review performance after occupation

The operation of the building should be checked following occupation by reviewing 6-12 months of services and heating bills (with the consent of the client or home owner). This is because evidence suggests that there is a 'Performance Gap' between what the home is 'designed' to achieve and what it does in practice.

Taken from the Zero Carbon Hub's Services Guide

PITFALLS TO AVOID

Assuming the building occupants know how to use the system

Where necessary, give training to occupants so that they know how to run the house efficiently. Provide a simple and non-technical Home User Guide for ongoing reference.

- Feedback from the industry has shown that without appropriate education, it can be easy for occupants to use a low-energy building inefficiently.
- This results in higher costs in use than expected. Whilst this may not impact you directly, it may harm your reputation – even if the issue is a result of occupant behaviour.

NOTE: This Guide is not a legal document and does not form part of a Building Regulations approved specification. It is for information and good practice purposes only. Consult your Building Control Officer for details on approved specifications and policy.

Published June 2016, version 1.0