A Review of Domestic and Non-Domestic Energy Performance Certificates in Scotland

Research report for the Scottish Government, Heat, Energy Efficiency and Consumers Unit

Final Report

January 2019

Scottish Government
Riaghaltas na h-Alba
gov.scot

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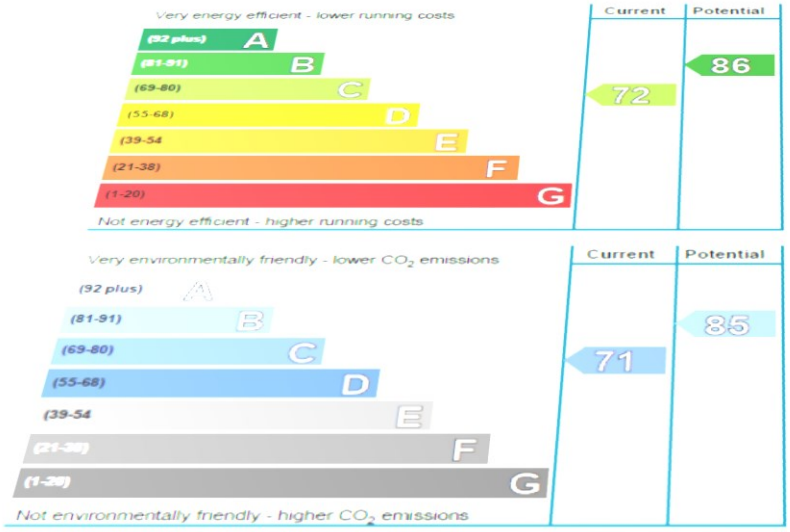
Alembic Research Ltd. in association with Energy Action Scotland and Dr Patrick Waterfield



Energy Efficiency Rating

This graph shows the current efficiency of your home, taking into account both energy efficiency and fuel costs. The higher this rating, the lower your fuel bills are likely to be.

Your current rating is **band C (72)**. The average rating for EPCs in Scotland is **band D (61)**.

The potential rating shows the effect of undertaking all of the improvement measures listed within your recommendations report.

Environmental Impact (CO_2) Rating

This graph shows the effect of your home on the environment in terms of carbon dioxide (CO_2) emissions. The higher the rating, the less impact it has on the environment.

Your current rating is **band C (71)**. The average rating for EPCs in Scotland is **band D (59)**.

The potential rating shows the effect of undertaking all of the improvement measures listed within your recommendations report.

ALEMBIC RESEARCH

in association with
Dr Patrick Waterfield

ENERGY ACTION SCOTLAND

23 March 2018

Executive Summary

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Glossary of Acronyms

BEIS	Business, Energy and Industrial Strategy (a UK government Department)
BREDEM	Building Research Establishment's Domestic Energy Model (underpinning methodology of SAP and RdSAP)
DEA	Domestic Energy Assessors (approved assessors in England and Wales for carrying out EPC assessments for existing dwellings)
DECs	Display Energy Certificates (operational ratings required on some non-domestic buildings)
ECO	Energy Company Obligation that ran from 2013 to 2015
ECO2	Energy Company Obligation that ran from 2015 to 2017
EES	Energy Efficienct Scotland (the long term Scottish Government strategy launched in 2018 to raise the energy efficiency standards of Scotland)
EESSH	Energy Efficiency Standard for Social Housing (the Scottish registered social landlord obligation to meet specified energy efficiency standards within their respective dwelling stocks by 2020)
EPBD	Energy Performance of Building Directive (the initial directive under this banner in 2002 initiated the requirement for EPCs on buildings when they were constructed, sold or rented. Subsequently updated and revised.)
EPCs	Energy Performance Certificates
EST	Energy Saving Trust (amongst many other activities, responsible for managing the Scottish EPC register)
EU	European Union (responsible for introducing the EPBD)
HEED	Home Energy Efficiency Database (a database owned and managed by the EST of energy efficiency installations and other housing-related data they have collated through their activities)
HEEPS ABS	Home Energy Efficiency Programme for Scotland: Area Based Scheme
LHEES	Heat and Energy Efficiency Strategies, and Regulation of District Heating consultation document (published by the Scottish Government in 2017, the published responses to which were one of the three source data sets used for this report)
MHCLG	Ministry of Housing, Communities and Local Government (a UK government ministry)

NCM	the National Calculation Methodology (the underpinning methodology for assessing the energy performance of new and existing non-domestic buildings in the UK)
PCDB	Product Characteristic Database (the database of a wide variety of energy performance related factors that underpin the SAP and RdSAP calculation models)
PRS	Energy Efficiency and Condition Standards in Private Rented Housing consultation (published by the Scottish Government in 2017, the published responses to which were one of the three sources of data sets used for this report)
RdSAP	Reduced Data Standard Assessment Procedure (the UK approved methodology for assessing the energy performance of existing dwellings for the production of EPCs. In effect, it is a subset of SAP)
RHI	Renewable Heat Incentive (a grant for funding renewable heating, available for both domestic and non-domestic buildings)
SAP	Standard Assessment Procedure (the approved UK methodology for assessing the energy performance of buildings for EPCs and Building Regulations)
SBEM	Simplified Building Energy Model (a calculation model that uses the NCM to assess the energy performance of non-domestic buildings for the production of EPCs). This includes Dynamic Simulation Modelling (DSM) software tools
SEEP	Scotland's Energy Efficiency Programme consultation document (published by the Scottish Government in 2017, the published responses to which were one of the three source data sets used for this report). SEEP was the precursor to EES (see above).
SERT	Scottish Energy Rating Tool (the initial model proposed for the production of EPCs in dwellings in Scotland. Superceded by RdSAP)

1. Introduction

Scottish Ministers announced in June 2015 that they would take long-term action to reduce energy demand and decarbonise the heat supply in the nation's residential, services and industrial sectors, designating energy efficiency as a national infrastructure priority[1]. With the publication of Energy Efficient Scotland: A Route Map in May 2018[2], the Scottish Government has set out an ambitious programme to reduce energy demand, to contribute to its climate change objectives whilst continuing to assist tackling fuel poverty and ensuring Scotland is "a good place to do business"[3]. Energy Performance Certificates (EPCs) will be an intrinsic component within this programme. "We have chosen to use EPCs to set the standard as our consultation in 2017 showed that EPCs are widely known and provide a clear way to model and understand the energy performance of a building."[4]

Energy Efficient Scotland (EES) is intended to be a coordinated programme to improve the energy efficiency of homes and buildings in the commercial, public and industrial sectors and to decarbonise their heat supply. EPCs and their underlying assessment methodologies will underpin the Scottish Government's actions to inform and drive improvements to properties, both domestic and non-domestic. What started out as an asset rating (that is, concerned about the construction of a building, the levels of insulation, the installed heating and hot water systems and their control, and lighting, irrespective of the occupants or their behaviour) has seen its purpose extended so that it has been used amongst other things to set standards for social housing landlords in Scotland[5], used to assess the carbon savings of the utility ECO and ECO2 programmes[6], and used in the assessment of grants under the Renewable Heat Incentive (RHI)[7]. EES will extend the purpose to which EPCs are put to into the realm of private rented sector compliance and then into the private owner occupier sector[8] by setting minimum energy efficiency standards to be achieved.

As a result of all of this planning for the future, the Scottish Government considered it an appropriate time to review the issues raised around the EPC system in current practice to ensure that going forward, the assessment process more accurately accounted for the Scottish built environment, and that information provided on the

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[1] http://www.parliament.scot/parliamentarybusiness/report.aspx?r=10002&i=91798&c=1836631#ScotParlOR
[2] http://www.gov.scot/Resource/0053/00534980.pdf
[3] http://www.gov.scot/Resource/0050/00505210.pdf
[4] see p7, Energy Efficient Scotland: A Route Map, http://www.gov.scot/Resource/0053/00534980.pdf
[5] for example, the Energy Efficiency Standard for Social Housing (ESSH), see https://beta.gov.scot/policies/home-energy-and-fuel-poverty/energy-efficiency-in-social-housing/
[6] for example, Energy Companies Obligation (ECO): Guidance for Suppliers published by Ofgem in 2013, available at https://www.ofgem.gov.uk/ofgem-publications/59015/energy-companies-obligation-eco-guidance-suppliers-15-march.pdf%20
[7] "If your Energy Performance Certificate (EPC) is dated after September 2012 it has all of the information on it that we need to calculate the payments you could get from the Domestic Renewable Heat Incentive." see https://www.gov.uk/renewable-heat-incentive-calculator
[8] http://www.gov.scot/Publications/2017/11/6863

EPC would usefully contribute to the strategic aim of making Scotland's buildings more energy efficient.

In December 2017, the Scottish Government commissioned a review of EPCs, seeking a robust assessment of issues raised around EPCs in various consultations to ensure that these issues are investigated, responded to and, where appropriate, addressed through further review. The intention of this examination of the EPC system is to answer the following research questions:

- Drawing on three recent consultation responses shaping the Scottish energy efficiency strategy, what concerns were raised in terms of using EPC-based building assessments to underpin the Scottish Government's actions to improve the energy performance of buildings?
- Which of these concerns merit a material change to the EPC-based building assessment methodologies?
- What changes can be made to EPC-based building assessment methodologies to address these concerns?
- What is the impact of the proposed changes on the information reported on domestic and non-domestic EPC certificates?
- What are the potential cost and time implications for implementing the proposed changes?
- What changes can be implemented within the scope and competencies currently defined for the role of EPC assessor?

A consortium of Scott Restrick of Energy Action Scotland (EAS), Dr. Patrick Waterfield, and led by Dr. Bill Sheldrick of Alembic Research was commissioned to carry out this work. The work programme agreed with the Scottish Government to complete this review involved various tasks:

- a literature review of the responses to three Scottish Government consultations that were carried out in 2017;
- a thematic analysis of those responses;
- using this thematic analysis to design and run four topic-based workshops;
- additional modelling and sensitivity analysis;
- the production of specific topic notes; and,
- the identification of possible actions, their impact, and cost and time implications that the Scottish Government could undertake.

This report presents the findings from the various tasks completed as part of this project. Any views expressed within the report belong to the process and the authors, and do not necessarily reflect the opinions or views of the Scottish Government.

2. Energy Performance Certification in Scotland

2.1 Introduction to EPCs

The provision of an EPC in Scotland can be summarised as a four-part process:

1. the assessment / survey of the building by an accredited person;
2. a calculation using a government approved methodology;
3. the lodgement of the results onto a national register to store the data; and,
4. the production of a certificate to an agreed Scottish format

The Scottish Government maintains an online resource containing 12 'Guidance Leaflets' on a range of issues relating to the provision of domestic and non-domestic EPCs in Scotland[9].

2.2 Background to Energy Performance Certificates

The original policy driver for the current system on EPCs was the European Union's (EU) Energy Performance in Buildings Directive 2002 (EPBD)[10] with its objective to promote the improvement of the energy performance of buildings across EU member states. The EPBD included, amongst others, the following requirements:

- to apply a methodology to calculate the energy performance of buildings (under Article 3);
- to ensure that when buildings with a total useful floor area over 1000 m^2 undergo major renovation, their energy performance is upgraded in order to meet minimum requirements in so far as this is technically, functionally and economically feasible. (under Article 6);
- to ensure that when buildings are constructed, sold or rented out, an energy performance certificate is made available to the owner or by the owner to the prospective buyer or tenant, as the case might be. The energy performance certificate for buildings was to include reference values and be accompanied by recommendations for the cost-effective improvement of its energy performance. (under Article 7); and,
- to ensure that the certification of buildings is carried out in an independent manner by qualified and/or accredited experts (under Article 10).

This directive was transposed into Scottish statute via The Energy Performance of Buildings (Scotland) Regulations 2008[11]. Under Section 6 of these regulations,

"6.— (1) An energy performance certificate must–

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[9] http://www.gov.scot/Topics/Built-Environment/Building/Building-standards/enerperfor/epcguidance
[10] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32002L0091
[11] http://www.legislation.gov.uk/ssi/2008/309/contents/made

(a) express the asset rating of the building in a way approved by the Scottish Ministers under regulation 7(b);
(b) include a reference value;
(c) include cost effective recommendations for improving the energy performance of the building;
(d) include the following information–
    (i) the address of the building;
    (ii) where the certificate is issued by a qualified member of an approved organisation, the name of the approved organisation of which the person issuing the certificate is a member; and
    (iii) the date on which it was issued; and
(e) be issued by a qualified member of an approved organisation for that category of building, or accepted by a verifier following submission of a completion certificate in accordance with regulation 41 of the Building (Procedure) (Scotland) Regulations 2004(1)."

In Scotland, the requirement to produce an EPC came into effect for all new buildings applying for a Building Warrant on or after May 1, 2007, and for existing buildings when constructed, sold or rented from January 4th, 2009. Since then, there have been various amendments and revisions to the calculation methodologies, the conventions governing the assessments of buildings, the format of the EPCs, and the Scottish EPC register.

2.3 Calculations Using Approved Methodologies

Underpinning the production of an EPC for a building in Scotland are various approved methodologies (i.e. SAP, RdSAP, and SBEM) which define the algorithms used to calculate the energy performance of a building, and approved computer software[12] that does the calculations. The two are inextricably linked.

Legislation on both domestic and non-domestic Building Regulations, and on housing matters, are devolved matters. That Scotland uses the same methodologies as the rest of the UK for assessing the energy performance of buildings was a matter of choice. During the period leading up to the formal introduction of the system of EPCs in Scotland, the Scottish Government via the then Scottish Building Standards Agency explored the development of a Scottish-derived system of rating the energy performance of buildings, the Scottish Energy Rating Tool (SERT).[13,14] Ultimately,

[12] there is a paper copy of the SAP worksheet included within the SAP manual, so that the calculation could be completed by hand using the look up tables included within the SAP manual
[13] "HUE was applied on behalf of the Scottish Building Standards Agency to meet the requirements of the EU Energy Performance of Buildings Directive, which calls for the issuing of performance certificates. When used by SBSA, HUE is known as the Scottish Energy Rating Tool, or SERT. Within the project, the HUE predictions were shown to be well aligned with the Government's simplified domestic sector method known as SAP" taken from http://www.esru.strath.ac.uk/Programs/EEff/index.htm
[14] see https://strathprints.strath.ac.uk/16468/

the Scottish Government took the decision in 2008 to adopt the same respective methodologies being used across the rest of the UK, that is,

- the Standard Assessment Procedure (SAP) for new domestic dwellings[15]
- the Reduced Data Standard Assessment Procedure (RdSAP) for existing domestic dwellings[16]
- the Simplified Building Energy Model (SBEM) / National Calculation Methodology (NCM) for new and existing non-domestic buildings[17]

The details that underpin these methodologies are published and all freely available online.[18,19,20]

Oversight of these three methodologies is maintained by two different UK government Departments: the Department of Business, Energy and Industrial Strategy (BEIS) lead on SAP and RdSAP; the Ministry of Housing, Communities and Local Government (MHCLG) lead on SBEM. Both operate in consultation with representatives of the devolved administrations (including Scotland), the Building Research Establishment (BRE), industry participants, software producers / accreditation schemes, and the national registers. BEIS has recently finished a public consultation exercise on the next iteration of SAP, to be known as SAP 10[21].

2.4 Assessment Process

The assessment process refers to the assessors, and the methods by which assessors collect the necessary data to be entered into the approved software to calculate the energy performance indicators. Different accreditation schemes exist for assessors in Scotland, and England and Wales, and Northern Ireland.

In Scotland, EPCs can only be produced by an assessor who is a member of an 'Approved Organisation'[22]. The Scottish Government has entered into formal agreements with various organisations whose members are considered to have the skills and expertise to produce EPCs and make recommendations on improvement measures. A list of Scottish EPC assessors is held by the Scottish EPC register[23]. A

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[15] see https://www.bre.co.uk/sap2012/page.jsp?id=2759
[16] ibid
[17] see https://www.uk-ncm.org.uk/
[18] For the NCM technical manual see https://www.uk-ncm.org.uk/filelibrary/SBEM-Technical-Manual_v5.2.g_20Nov15.pdf
[19] For current SAP 2012 v9.92 manual see https://www.bre.co.uk/filelibrary/SAP/2012/SAP-2012_9-92.pdf
[20] For current RdSAP v9.93, see https://www.bre.co.uk/filelibrary/SAP/2012/RdSAP-9.93/RdSAP_2012_9.93.pdf
[21] [21] See Department of Business, Energy & Industrial Strategy (2017) "Changes to Government's Standard Assessment Procedure (SAP): Government Response", available at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/660478/Government_Response_-_Changes_to_SAP_FINAL-v2.pdf
[22] http://www.gov.scot/Topics/Built-Environment/Building/Building-standards/enerperfor/epcorgprg
[23] https://www.scottishepcregister.org.uk/

Scottish assessor is not registered to issue EPCs in England and Wales without also being registered with an EPC accreditation scheme there; an English EPC Assessor cannot issue EPCs in Scotland without becoming a member of a Scottish Approved Organisation that has signed a protocol agreement with the Scottish Government.

To assist with promoting consistency between assessors, conventions and guides have been published and these too are online.[24,25,26] Three separate conventions working groups overseen by BEIS and MHCLG respectively, include representatives of the devolved administrations (including Scotland), the Building Research Establishment (BRE), industry participants, software producers / accreditation schemes, and the national registers. The BRE chairs the working groups on SAP and RdSAP, while a representative of Landmark (the company that administers the EPC Register for England, Wales and Northern Ireland EPCs) chairs the SBEM/NCM working group.

2.5 Reporting Process

The reporting process here refers to the physical output from the assessment of the energy performance of a building, that is, the actual EPC and the associated energy advice report and recommendations.

While the EPBD requires that an EPC and an energy advice report be produced for a building at the point that the building is constructed, sold or rented out, the EPBD does not specify the appearance or content of these items. That EPCs in Scotland look different from those issued in England, Wales and Northern Ireland is the direct result of decisions taken by the Scottish Government on the format and content of Scottish EPCs. These formats are used to generate EPCs from data held on the Scottish EPC register and also by Approved Software in situations where the EPC is generated from within the software (e.g. a draft EPC).

The EPC format for existing Scottish domestic dwellings changed considerably on 1 October 2012, and for all other Scottish building type EPCs on 28 January 2013.

2.6 Registering an EPC in the Scottish National Database

The EPBD does not require the establishment of a national database to store EPCs or the information collected during the assessment or the results produced by the calculations. From the perspective of a national data archive, however, establishing such a register makes a lot of sense, as EPCs contain detailed information pertaining to the energy efficiency characteristics of the dwelling stock.

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[24] For SAP 2012, see https://www.bre.co.uk/filelibrary/SAP/2012/SAP-Conventions.pdf
[25] For RdSAP 2012 v9.93, see https://www.bre.co.uk/filelibrary/SAP/2012/RdSAP-Conventions-10_0---from-31-December-2017.pdf
[26] For NCM in Scotland, see http://www.gov.scot/Resource/0048/00486061.pdf

Initially, EPCs for existing dwellings were lodged within the Energy Saving Trust's (EST) Home Energy Efficiency Database (HEED) (from 2009 to October 2012). New dwelling and non-domestic building EPCs were issued as paper copies by assessors using the relevant software, but they were not lodged separately. A separate Scottish Register was established for existing dwelling EPCs lodged from October 2012 onwards, and opened up to take EPCs for new build dwellings and for new and existing non-domestic buildings from January 2013.

Access to the Scottish EPC register[27] is open to anyone to search online for an EPC either by a postcode or by the EPC's unique registration number (i.e. its Report Reference Number (RRN)), which is on the EPC, subject to the person agreeing to abide by the Terms and Conditions of use of the website. If searched by the RRN, the website will only bring up the one relevant EPC. When searched by postcode, it will bring up a list of all the addresses at that postcode where an EPC has been issued, provide the respective RRNs, and allow the PDF of the EPC to be downloaded – but only the most recent one issued. When a new EPC for a property is lodged, any existing EPC is overwritten on the public interface of the register, though the older EPCs are still held within the system.[28]

2.7 Going forward with EPCs in Scotland

For Scotland going forward, the fundamental aim of this report is to address identified concerns within the EPC process from a Scottish perspective, identifying where changes could be made, with the intention of making recommendations that will allow the EPC process to more accurately reflect the Scottish built environment, and by improving EPCs where practical and appropriate.

[27] https://www.scottishepcregister.org.uk/

[28] It is has been reported to the authors of this report that at least one utility has an agreement with the Scottish Register to search through back EPCs as part of its quality assurance activities with regard to ECO2 and ECO2T.

3. Research Methodology

The Scottish Government published an analysis of responses to the three public consultations, and provided a generalised summary of the comments. This analysis did not examine in detail specific critical comments on the effectiveness of EPCs in Scotland, nor did it explore how these issues could be addressed going forward. The research methodology employed to complete this review of domestic and non-domestic EPCs comprises of several specific tasks: a literature review, thematic analysis, workshops and sensitivity analysis of various issues.

3.1 Literature Review

Rather than the generalised summaries of the respective three consultation exercises that the Scottish Government published in November 2017, the initial focus of this project was the actual individual public responses received via the three separate public consultation exercises set out in section 3.1.1 below. These responses are all published on-line.

The objective of this desk review was therefore to identify, collate and categorise specific concerns about the SAP, RdSAP, and SBEM / NCM methodologies arising from the three separate consultation exercises, to allow a more detailed analysis of the nature of the concerns, and possible actions going forward. This thematic analysis would be used to inform the workshop discussion topics and subsequent identification of possible actions.

3.1.1 Data Sources

The primary sources of data to inform this report were the published responses[29] to three separate public consultations contributing to the development of Energy Efficient Scotland (previously SEEP) and other related policy matters:

1. **Scotland's Energy Efficiency Programme (SEEP)**[30] - *opened 24 January 2017 and closed 30 May 2017*
   - Scottish Government analysis of the responses received to the consultation on Scotland's Energy Efficiency Programme (SEEP) - published November 14, 2017[31]
   - 98 Published Responses[32]
2. **Heat and Energy Efficiency Strategies, and Regulation of District Heating (LHEES)**[33] - *opened 24 January 2017 and closed 18 April 2017*

[29] Only responses from respondents who gave permission to be published on-line were assessed. The authors of this report had no access to responses where the author(s) of a response withheld permission for it to be published on-line.
[30] https://consult.gov.scot/energy-and-climate-change-directorate/scotlands-energy-efficiency-programme/
[31] http://www.gov.scot/Publications/2017/11/6738
[32] https://consult.gov.scot/energy-and-climate-change-directorate/scotlands-energy-efficiency-programme/consultation/published_select_respondent

- Scottish Government analysis of Responses to the Consultation on Heat and Energy Efficiency Strategies, and Regulation of District Heating – published November 14, 2017[34]
- 84 Published Responses[35]

3. **Energy Efficiency and Condition Standards in Private Rented Housing (PRS)**[36] - *opened 7 April 2017 and closed 30 June 2017*
   - Scottish Government analysis of responses to the public consultation on energy efficiency and condition standards in private rented housing – published November 14, 2017[37]
   - 161 Published Responses[38]

3.2 Thematic analysis of the public consultation responses

Text searches were carried out on 343 individual responses to the three public consultations using 17 different search terms (see Appendix A.1 for the full list of the initial search terms used). These search terms were identified through an iterative process involving reading the initial consultation documents, the consultation questions, the individual published responses, and the concerns of this review. This search exercise was not just concerned with the consultation document questions specifically addressing SAP, RdSAP, SBEM or EPC issues, but drew from across the responses, to inform on the breadth of EPC-related issues.

Of the 343 published responses, 101 were categorised as having 'no relevant comment' with regard to SAP, RdSAP, SBEM or EPC issues. The remaining 242 responses generated 1066 comments that were identified as being of concern to this review, and then extracted and collated within a spreadsheet. Each comment was identified by its response number[39] and the consultation it was extracted from.

Subsequently, the 1066 contributions were reviewed three times by the same person: first to assign the three metatags to each comment; then, to allocate the response to one of 18 broad themes along with a descriptor; and finally, to ascribe a keyword to provide an overall summary of the response content. This approach allowed the individual responses subsequently to be collated into common themes and topics for further discussion and analysis in the workshops and in this report.

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[33] https://consult.gov.scot/energy-and-climate-change-directorate/local-heat-and-energy-efficiency/
[34] http://www.gov.scot/Publications/2017/11/4994
[35] https://consult.gov.scot/energy-and-climate-change-directorate/local-heat-and-energy-efficiency/consultation/published_select_respondent
[36] www.gov.scot/Publications/2017/04/2510
[37] http://www.gov.scot/Publications/2017/11/6863
[38] https://consult.gov.scot/better-homes-division/energy-efficiency-programme/consultation/published_select_respondent
[39] The individual published responses were identified on the website by either a unique response number or by the name of the organisation or individual making the response. When these latter responses were opened, a unique response number for each was found within. This number was assigned to these responses so that the spreadsheet was anonymous collation of the responses.

A graphic representation of this analysis process is provided in Figure 3.2.1 below.

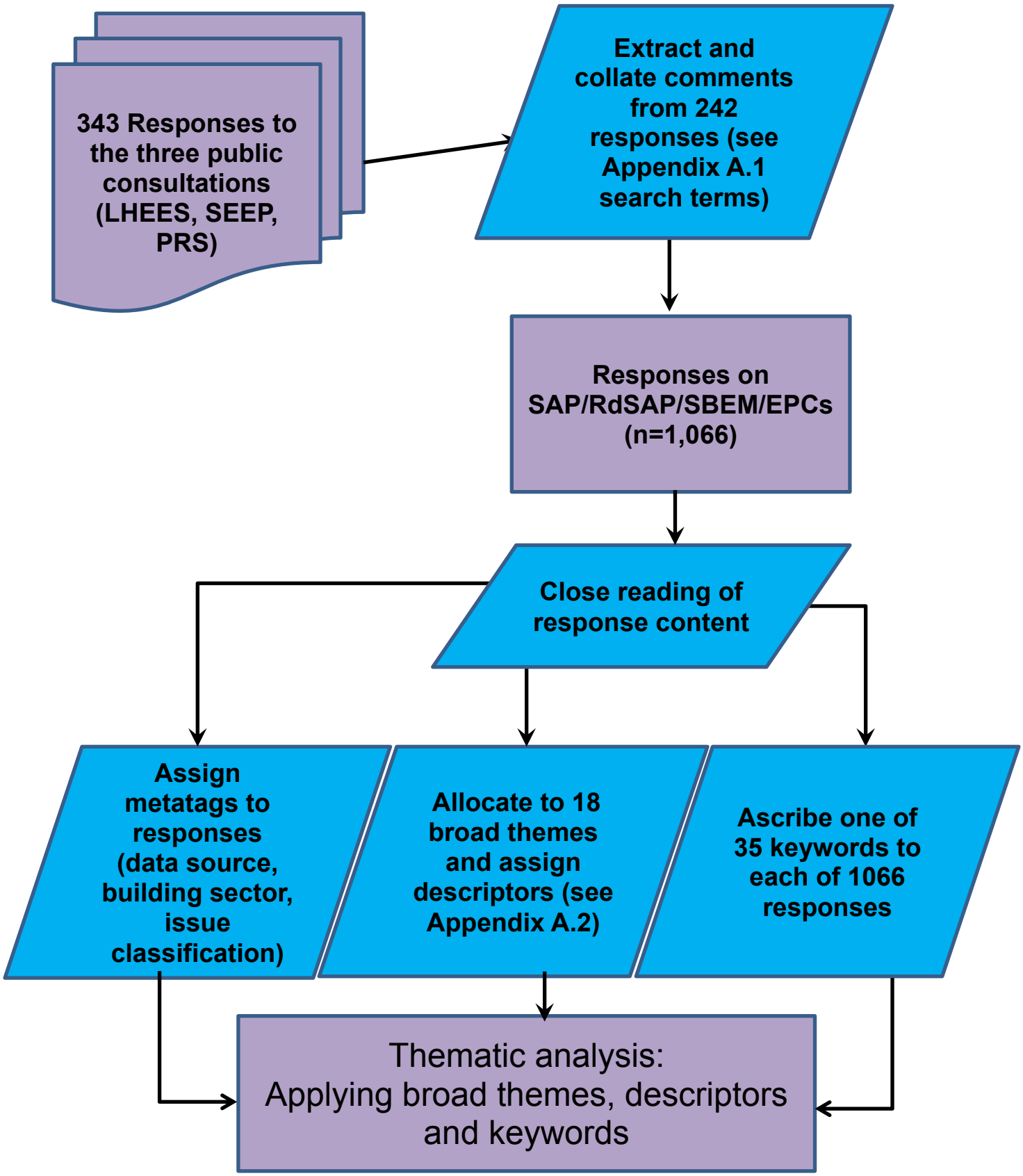

Figure 3.2.1 - Process diagram describing the method for analysing and categorising comments relating to the use of EPCs in buildings

3.2.1 Metatags

All 1,066 contributions were categorised according to three different metatags (see Figure 3.2.2).

Figure 3.2.2 – Three metatags used to categorise responses

- **Building Sector** (domestic / non-domestic / both): that is, the response pertained specifically to domestic buildings or non-domestic buildings, or both (i.e. the response concerned EPCs or assessment of the energy performance of buildings but did not explicitly reference either SBEM, or SAP or RdSAP so, in principle, it could be applied equally to either building type).

- **EPC Comment** (critical / neutral / positive): that is, the response was explicitly 'critical' (i.e. negative in tone) of SAP, RdSAP, SBEM or EPCs; 'neutral' if it did not explicitly mention SAP, RdSAP, SBEM, or EPCs within its content; or 'positive' if it explicitly mentioned SAP, RdSAP, SBEM or EPCs in a positive way.

- **Issue Classification** (calculation / assessment / reporting / database): that is, the response was assigned to one of the four stages of the EPC process (as set out in section 2.1):

    - **calculation**, that is, the response was concerned with either the BREDEM methodology, or the SAP, RdSAP or SBEM calculation methodologies used to define the energy models in theory, or with how these methodologies are represented within the calculation models and software via algorithms or data requirements.

    - **assessment**, that is, the response was concerned with the assessor, the data collected by the assessor, the conventions governing the collection of data by the assessor, the inputting of the data into the software by the assessor, or the quality assurance procedures overseeing the assessor.

    - **reporting**, that is, the response was concerned with the physical output of the EPC process: the certificate or the attached advice report and recommendations, or the process used to produce the recommendations

    - **database**, that is, the response was concerned with the storage of the EPC-related data on the national register, access to the data, or retrieval of the data from the register.

3.2.2 Broad themes

Each of these 1,066 contributions was then assigned and described within one or more of 18 broad themes (see Figure 3.2.3 below). Additional descriptors were applied within each of these broad themes to enable more detailed analysis of the broad themes (see Appendix A.2). A response could be assigned to any number of these 18 broad themes.

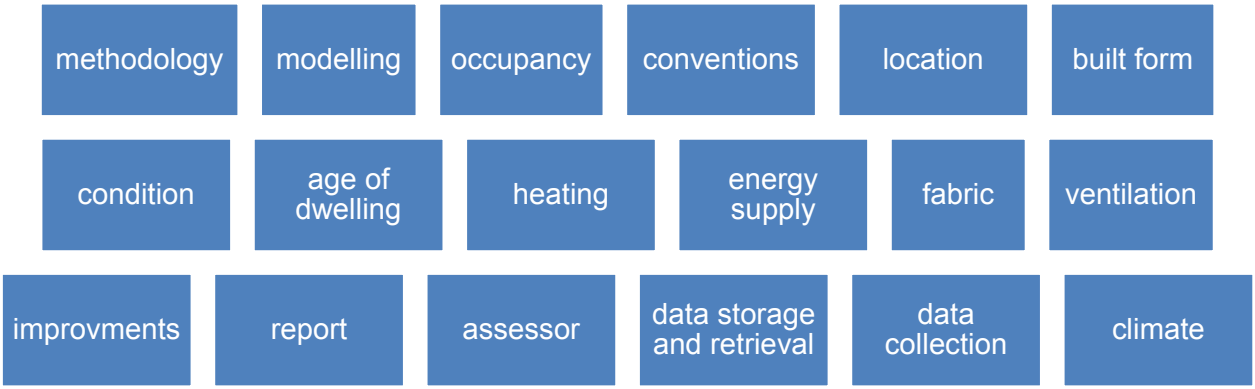

Figure 3.2.3 – 18 broad themes used to categorise responses

3.2.3 Keywords

Finally, each contribution was described by one of 35 keywords (see Figure 3.2.4 below), to allow further filtering of the contributions as necessary to inform the thematic and topic analysis. Unlike the broad themes, a response was described by a single keyword / phrase. This approach resulted in some responses being split into several parts to adequately describe their content.

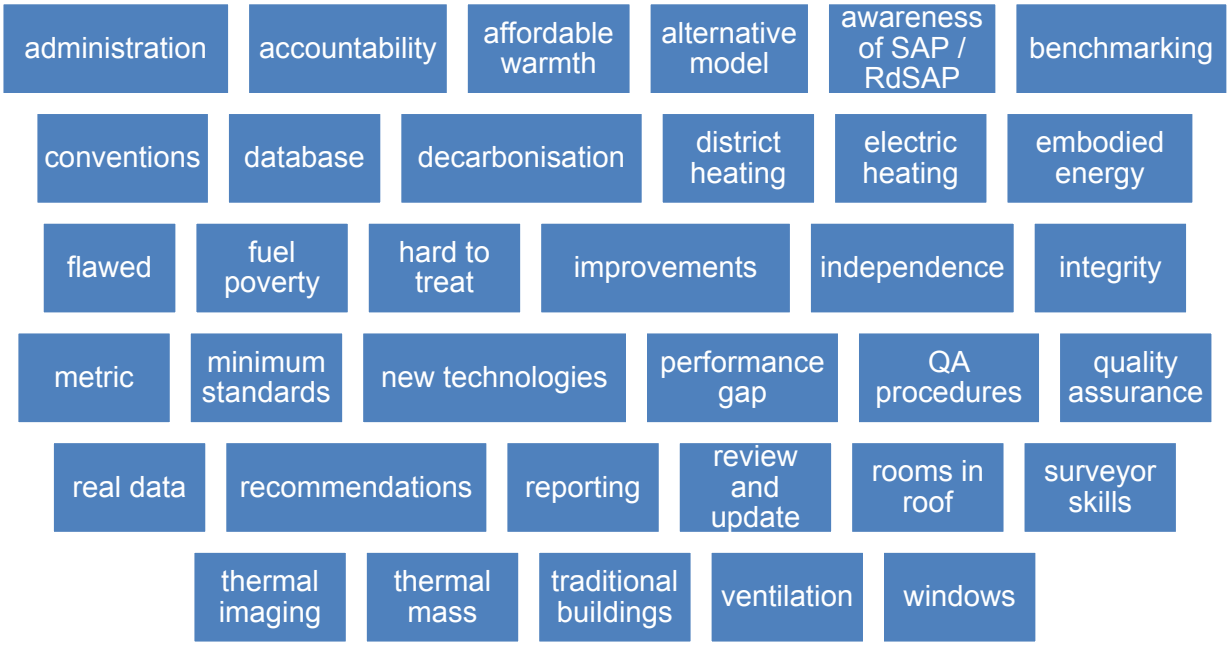

Figure 3.2.4 – 35 keywords assigned to responses

3.3 Workshops

Rather than limit this research project to a desk analysis of the responses, the project sought to open the discussion up to a wider public forum, to canvass opinion on the EPC issues and possible actions going forward.

The thematic analysis informed the identification and content of the topics for presentation at four workshops held around Scotland during February and March 2018. These events were day-long open events designed with the intention to be pro-active in canvassing discussion and opinions on the topics, and allowing feedback to be captured from each participant. Presentations on the broad themes distilled from the analysis were introduced with evidence provided by the research team, followed by a facilitated discussion with the participants. Participants were asked to record any comments and/or their views of this evidence within structured workbooks to allow the research team to determine if this evidence had any bearing on consolidating or changing opinions on the effectiveness of the EPC system in Scotland.

The discussion at the workshops, and the feedback captured in the workbooks was used in the topical analysis presented in Section 6, and in the identification of possible actions going forward.

3.4 Supplementary Topic Notes: Additional Modelling and Sensitivity Analysis

As part of this project, the research team produced six supplementary topic notes on specific EPC-related concerns with regard to domestic dwellings that came out of the responses to the three public consultations. These topic notes included more detailed discussion on issues relating to:

- assessing traditional buildings;
- assessing rooms in the roof;
- using default and full window measurement data within the RdSAP program;
- comparing the impact of RdSAP ventilation defaults within a full SAP program;
- assessing the impact of changing the thermal mass parameter within RdSAP; and,
- comparing the differences between using a full SAP program and RdSAP with regard to assessing community heating.

The underlying intention of these supplementary topic notes and sensitivity analysis was to produce empirical data to inform the workshop discussions rather than rely on anecdotal evidence and discourse alone. These topic notes are published in a separate addendum to this report.

3.5 Topic Analysis and Identification of Possible Actions

The thematic analysis, workshop presentations, workshop feedback, supplementary topic notes and sensitivity analysis were distilled down to topical discussions on the SAP, RdSAP, SBEM and EPC-related issues and, most importantly, to identify possible actions to enhance the EPC-related processes going forward.

In identifying possible actions, they have been categorised (and colour-coded in this report) using the issue classification breakdown set out in section 3.2.2 above – that is, calculation, assessment, reporting and database–related actions. These categories not only reflect the four stages of the EPC process, but how a potential action is categorised has implications for how it can be dealt with, and by whom.

Figure 3.5.1 – 4 categories for possible EPC-related actions

Calculation actions would need changes to the underlying BREDEM / NCM methodology and / or the calculation models that are used to calculate the energy performance of a building, and its SAP score (i.e. SAP or RdSAP) or its Building Energy Performance Rating (i.e. SBEM). For example, these changes may include adding something that is not included currently within BREDEM, or SAP, RdSAP and SBEM/NCM, or modifying the equations, algorithms, or the default reference data used within the models.

These actions are currently within the remit of, and lead by, two UK government departments, BEIS and MHCLG. The Scottish Government has an input into the discussions, but so too does the wider industry. Major changes in the underlying methodologies do not occur quickly. The development of 'SAP 10' (i.e. the replacement for SAP 2012) provides a case in point. Proposed changes went out to consultation in November 2016, with a closing date of end of January 2017. The government response to the consultation was published in November 2017, with the formal SAP 10 document only published in July 2018[40], and it may be another year or more before it is fully implemented in practice[41]. Yet, even before the preparation of the consultation, there was more than a year of work in the preparation of a draft SAP 2016[42] and a number of technical discussion documents[43]. Changes to the underlying methodologies are likely to have a time frame of at least 3 years.

As the underlying methodologies are empirically-based, changes in SAP, RdSAP and SBEM are based on new data. If a change to the underlying methodology also

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[40] http://files.bregroup.com/SAP/SAP-10.0_24-07-2018.pdf
[41] See https://www.buildenergy.co.uk/blog/sap-10-released-whats-new/
[42] SAP 2016 was renamed formally as SAP 10 with the publication of the government response on SAP.
[43] See https://www.bre.co.uk/sap2016/page.jsp?id=3618

requires data collection to inform or validate the process, then that will increase the time required to make a change.

Equally, simply making changes to the calculation software involves time for the accreditation organisations to make the changes, and then for the software to be tested and approved.

Assessment actions would need changes to the conventions, quality assurance procedures, or training that inform the data collection and survey of a building. Changes to conventions are currently within the remit of SAP, RdSAP and SBEM working groups, and any proposed changes signed off by BEIS or MHCLG respectively. Again, the Scottish Government has an input into these working groups, as does the wider industry. Simply changing a convention (that requires no change to the software) is likely to take up to a year to implement. Setting new training standards or qualifications would take time to develop, agree, and then implement. Once they were agreed, training programmes would need to be revised and rolled out. Invoking new quality assurance procedures, which falls within the remit of the Scottish Government, is likely to take at least 2 years to agree with the accreditation organisations and to roll out.

Reporting actions would incur changes to the format of the EPC or the associated advice report and / or recommendations, or the underlying protocols that determine which recommendations appear or do not appear on the EPC, their order, and the technical specification of the recommendation that is modelled (i.e. Appendix T of the SAP methodology).

The format of the EPC or its associated advice report and the recommendations are within the remit of the Scottish Government. Changing the format would impact on the accreditation organisations and software providers where it would require software changes. Changing the basis used to produce the recommendations (i.e. Appendix T), either to produce an alternative format for the recommendations, or to develop a completely different approach such as the least cost improvements to meet a minimum defined standard, would require changes to the methodology and to the software. Simply adding or revising text within the existing EPC format would take from a few months to a year to agree, approve and to implement. A more fundamental change to the calculation and presentation of recommendations would take more than a year to implement.

Database actions would need changes to the way we store, access and or retrieve the EPC-related information from the national register. Again, changes to the database arrangements are within the Scottish Government remit, but the actual database is managed by EST Scotland who are appointed as ‘keeper of the register’. Changes to the database arrangements would require to be programmed and implemented as part of an overall development plan for the register.

All possible actions identified across the four categories above were also assessed against an indicative framework with regard to the rationale for the change, the time

frame needed to implement the change, the cost of making the change, the impact on the rating, and the magnitude of the building stock affected (see Figure 3.5.1).

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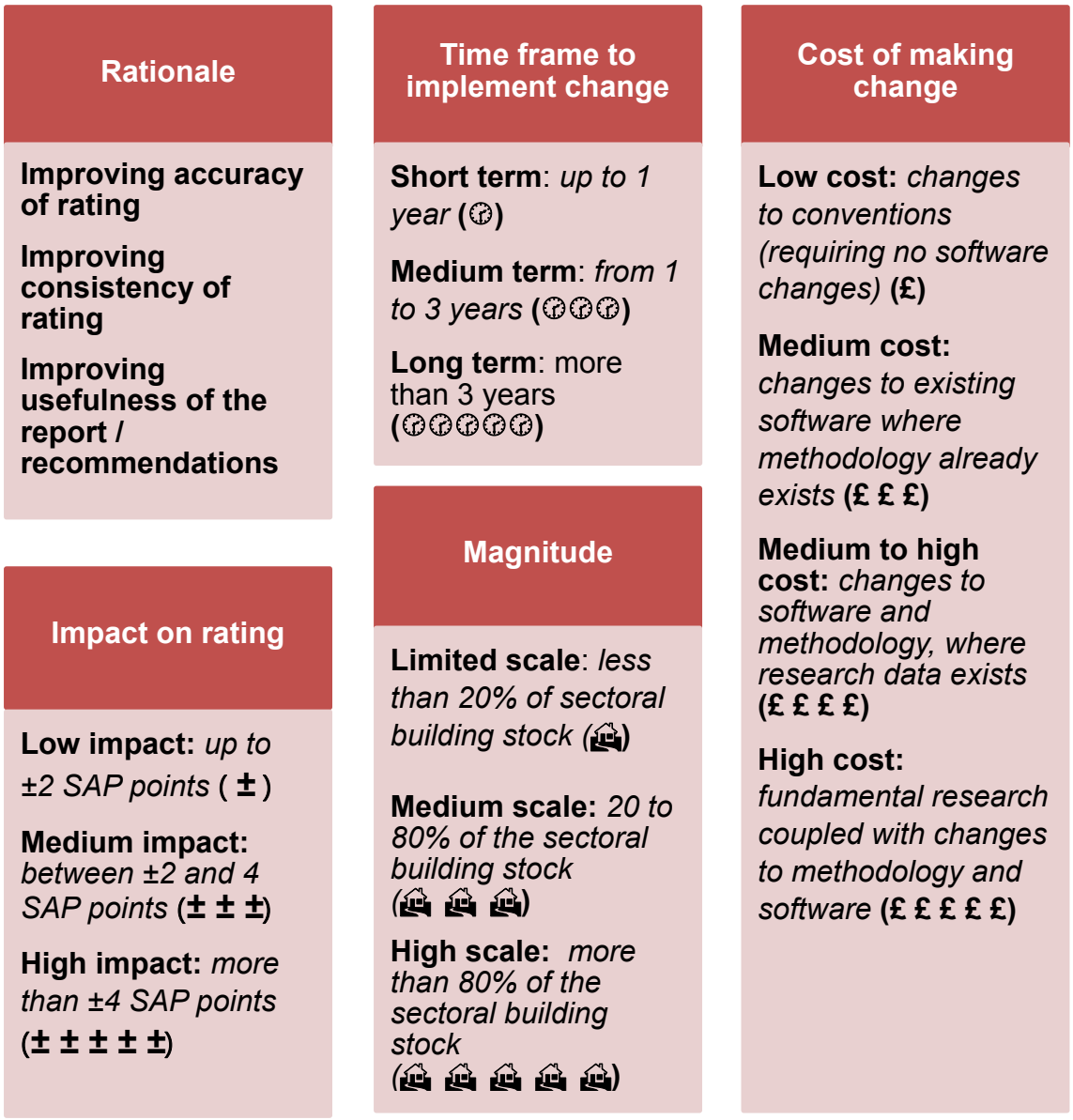

Figure 3.5.1 – Indicative framework to assess rationale, time frame, cost, impact and magnitude of possible changes to EPC-related possible actions

4. Thematic analysis

Within the spreadsheet holding the contributions extracted from the three consultation responses, each contribution was identified by its data source (i.e. LHEES, SEEP or PRS), assigned values for each of the three metatags (i.e. building sector, the nature of the EPC comment, and the issue classification), allocated to one or more broad themes, and allocated a keyword. This purpose of this activity was to allow the various individual contributions to be collated into common themes and topics, effectively, to take the diverse array of individual contributions and build a new narrative to inform discussion in the workshops and the topical analysis carried out in this report.

4.1 Frequency analysis of responses

The PRS consultation was the largest source of contributions on SAP, RdSAP, SBEM and EPC-related issues considered in this review: the total number of individual responses with comments; the total number of comments; the mean number of comments identified within a response; and the least number of responses where no relevant comment was identified. At the other end of the spectrum was the LHEES consultation, with the lowest number of individual responses, the fewest number of comments, the lowest mean number of comments, and the highest number of responses where no relevant comment was identified (see Table 4.1.1). The SEEP and PRS consultations included specific questions with regard to SAP, RdSAP, SBEM and / or EPCs; LHEES did not.

Data Source	Total number of individual responses (n=343)	Number of individual responses where 'no relevant comment' identified (n=101)	Number of individual responses where relevant comments identified (n=242)	Total number of comments identified (n=1066)	Mean number of comments per response where relevant comment identified
LHEES	84	57	27	51	1.89
SEEP	98	36	62	226	3.64
PRS	161	8	153	789	5.16

Table 4.1.1: Public consultations and SAP, RdSAP, SBEM and EPC-related contributions

Contributions focussed specifically on domestic building-related issues accounted for almost half of all of the contributions (i.e. 49.7%), while non-domestic building specific comments accounted for under 3%; contributions attributable to both domestic and non-domestic building accounted for the rest (i.e. 47.4%) (see Table 4.1.2). Overwhelmingly, the domestic building-related issues came from the PRS consultation (i.e. 87.5%), which is not surprising as this consultation was concerned explicitly about setting standards in private rented dwellings; only 4 of the 789 PRS contributions (i.e. 0.5%) were concerned with non-domestic buildings. The SEEP consultation specifically included mention of SBEM within its consultation questions, so it is not surprising that the largest number of non-domestic building specific

comments were identified within this consultation (i.e. 64.5%), but the non-domestic building specific comments accounted for only a small part of all the SEEP comments included here (i.e. 8.8%).

Building Sector	Count (n=1066)	LHEES (n=51)	SEEP (n=226)	PRS (n=789)
Non-domestic	31 (2.9%)	7 (row 22.5%) / (column 13.7%)	20 (row 64.5%) / (column 8.8%)	4 (row 12.9%) / (column 0.5%)
Domestic	530 (49.7%)	16 (row 3.2%) / (column 31.3%)	50 (row 9.4%) / (column 22.1%)	464 (row 87.5%) / (column 58.8%)
Both	505 (47.4%)	28 (row 5.5%) / (column 54.9%)	156 (row 30.9%) / (column 69.0%)	321 (row 63.6%) / (column 13.7%)

Table 4.1.2: Building sector focus of public consultations responses on SAP, RdSAP, SBEM and EPC-related contributions

In terms of the tone of the EPC-related comments, the overwhelming majority were deemed to be neutral overall (i.e.74.2%), and within each of the three consultations (i.e. 98% of LHEES comments, 62.8% of SEEP comments, and 75.9% of PRS comments (see Table 4.1.3). Critical comments accounted for less than 20% of the total (i.e. 18.9%) and positive comments, 6.8%. While the PRS consultation accounted for the largest number of the critical comments, critical comments accounted for a larger percentage of the SEEP responses (i.e. 29.2%) than the other two consultations (17.0% of the PRS comments and just 2% of the LHEES comments).

EPC Comment	Count (n=1066)	LHEES (n=51)	SEEP (n=226)	PRS (n=789)
Critical	202 (18.9%)	1 (row 0.5%) / (column 2.0%)	67 (row 33.2%) / (column 29.6%)	134 (row 66.3%) / (column 17.0%)
Neutral	791 (74.2%)	50 (row 6.3%) / (column 98.0%)	142 (row 18.0%) / (column 62.8%)	599 (row 75.7%) / (column 75.9%)
Positive	73 (6.8%)	0 (row 0%) / (column 0%)	17 (row 23.3%) / (column 7.5%)	56 (row 76.7%) / (column 7.1%)

Table 4.1.3: Tone of EPC comment of public consultations responses on SAP, RdSAP, SBEM and EPC-related contributions

Across the three consultations, the responses were roughly evenly spread three ways across the calculation, assessment or reporting issue classification categories; database category only accounted for 2.3% of the overall responses (see Table 4.1.4). Differences in the concerns are seen in the individual consultation documents: calculation-related responses accounted for almost half of the LHEES and SEEP responses, but only a quarter of the PRS responses. Within the PRS responses, the assessment-related responses accounted for 40% and the reporting-related responses accounted for a third. While database-related responses were low overall, they accounted for a quarter of the LHEES responses.

Issue Classification	Count (n=1066)	LHEES (n=51)	SEEP (n=226)	PRS (n=789)
Calculation	319 (29.9%)	24 (row 7.5%) / (column 47.1%)	109 (row 34.2%) / (column 48.2%)	186 (row 58.3%) / (column 23.6%)
Assessment	402 (37.7%)	11 (row 2.7%) / (column 21.6%)	63 (row 15.7%) / (column 27.9%)	328 (row 81.6%) / (column 41.6%)
Reporting	321 (30.1%)	3 (row 0.9%) / (column 5.9%)	50 (row 15.6%) / (column 22.1%)	268 (row 83.5%) / (column 34.0%)
Database	24 (2.3%)	13 (row 54.2%) / (column 25.5%)	4 (row 16.7%) / (column 1.8%)	7 (row 29.2%) / (column 0.9%)

Table 4.1.4: Initial issue classification of public consultations responses on SAP, RdSAP, SBEM and EPC-related contributions

4.2 Broad Themes

The individual responses were allocated to, and further described within one or more of 18 broad themes (see Appendix A.2 for the 18 broad themes and the descriptors). A frequency analysis of the broad themes is set out in Table 4.2.1. The frequency analysis of the broad themes is broken down by the data source in Table 4.2.2, and by the issue classification in Table 4.2.3.

Broad Themes	Frequency
Methodology	**793**
Modelling	**722**
Report	**299**
Assessor	**290**
Improvements	**289**
Occupancy	**128**
Built Form	**103**
Convention	75
Location	65
Heating	64
Fabric	56
Data Collection	52
Data Storage & Retrieval	33
Energy Supply	29
Climate	26
Condition	19
Age of Dwelling	12
Ventilation	11

Key
*Broad themes in **RED** account for more than 250 contributions*
*Broad themes in **YELLOW** account for between 100 and 250 contributions*

Table 4.2.1 - Frequency analysis of broad themes applied to contributions extracted from the responses to the three public consultations

The broad themes of methodology and modelling-related issues dominated the responses across all three public consultations. Beyond that, occupancy, database, and data-storage issues were of greater concern to the LHEES respondents than to the SEEP and PRS respondents. In contrast, assessor, reporting and improvement related issues were of greater concern to the PRS respondents than to the LHEES and SEEP respondents.

The broad themes of methodology and modelling-related issues dominated the responses across all the issue classification categories. Maybe not surprisingly, assessor related issues were the most frequently identified broad theme within the assessment classification, while reporting and improvement related issues were heavily identified within the reporting classification. Overall, the database classification accounted for significantly fewer issues than did the calculation, assessment and reporting classifications.

Broad Themes	LHEES	SEEP	PRS
Methodology (n=794)	48	191	555
Modelling (n=725)	44	170	511
Report (n=299)	3	46	250
Improvements (n=289)	5	37	247
Assessor (n=286)	2	31	253
Occupancy (n=128)	20	50	58
Built Form (n=106)	0	10	96
Conventions (n=88)	0	17	71
Location (n=65)	1	12	52
Heating (n=64)	9	23	32
Fabric (n=56)	0	47	9
Data Collection (n=52)	24	16	12
Data Storage & Retrieval (n=33)	17	4	12
Energy Supply (n=29)	0	14	15
Climate (n=26)	6	6	14
Condition (n=19)	1	4	14
Age of Dwelling (n=12)	0	4	8
Ventilation (n=11)	2	1	8

Table 4.2.2 - Frequency analysis of Broad Themes by public consultation data source

Broad Themes	Calculation	Assessment	Reporting	Database
Methodology (n=794)	316	153	311	14
Modelling (n=725)	314	139	260	12
Report (n=299)	39	76	184	0
Improvements (n=289)	37	75	177	0
Assessor (n=286)	0	278	8	0
Occupancy (n=128)	65	21	34	8
Built Form (n=106)	33	39	34	0
Conventions (n=88)	16	58	14	0
Location (n=65)	26	17	21	1
Heating (n=64)	42	11	9	2
Fabric (n=56)	22	25	9	0
Data Collection (n=52)	18	8	6	20
Data Storage & Retrieval (n=33)	5	2	4	22
Energy Supply (n=29)	23	3	3	0
Climate (n=26)	19	2	0	5
Condition (n=19)	1	18	0	0
Age of Dwelling (n=12)	3	7	2	0
Ventilation (n=11)	3	8	0	0

Table 4.2.3 - Frequency analysis of Broad Themes by Issue Classification

A pivot table analysis of the broad themes by data source, building sector, and issue classification is set out in Appendix A.4)

Additional descriptors were applied within each of these broad themes to allow more detailed topic analysis and identification of specific issues to occur for the workshops. These will be explored more fully in the next section.

4.3 Keywords

Finally, each contribution was described by one of 35 keywords (see Appendix A.3), to allow further filtering of the contributions, as necessary to inform the more detailed topic analysis and identification of specific issues to occur for the workshops. A frequency analysis of the broad themes is set out in Table 4.3.1. It can be seen that three keywords (i.e. surveyor skills, recommendations, and performance gap) each account for more than 10% of the response contributions. Two more (i.e. metric and minimum standards) account for between 5 and 10% of the response contributions. In total, these five keywords account for 60.9% of all the responses.

Keyword	Total (n=1066)
surveyor skills	**208**
recommendations	**178**
performance gap	**139**
metric	**70**
minimum standards	**54**
awareness of SAP	41
decarbonisation	32
traditional buildings	31
new technologies	26
QA procedures	24
benchmarking	23
database	22
quality assurance	21
district heating	19
real data	19
conventions	17
integrity	17
flawed	16
review and update	16
alternative model	15
independence	12
electric heating	11
reporting	9
ventilation	9
accountability	6
fuel poverty	6
thermal mass	5
administration	4
affordable warmth	4
thermal imaging	4
embodied energy	2
hard to treat	2
windows	2
improvements	1
room in roof	1

Key
Keywords in **RED** account for more than 10% of the contributions
Keywords in **YELLOW** account for between 5 and 10% of the contributions

Table 4.3.1 - Frequency analysis of keyword applied to contributions extracted from the responses to the three public consultations

The frequency analysis of the broad themes is broken down by the data source in Table 4.3.2, and by the issue classification in Table 4.3.3.

The overall rank ordering of the keywords is influenced heavily by the PRS responses: the five most common keywords overall are also the five most common within the PRS responses (see Table 4.3.2). With SEEP, the most common three keywords were performance gap, benchmarking and decarbonisation; while amongst the LHEES responses, the most common keywords were real data, district heating and database.

Keyword (n=1066)	LHEES (n=51)	SEEP (n=226)	PRS (n=789)
surveyor skills (n=208)	1	12	195
recommendations (n=178)	2	17	159
performance gap (n=139)	4	67	68
metric (n=70)	1	13	56
minimum standards (n=54)		2	52
awareness of SAP (n=41)		13	28
decarbonisation (n=32)	2	18	12
traditional buildings (n=31)		2	29
new technologies (n=26)		8	18
QA procedures (n=24)		5	19
benchmarking (n=23)		20	3
database (n=22)	10	3	9
quality assurance (n=21)		7	14
district heating (n=19)	10	3	6
real data (n=19)	13	4	2
conventions (n=17)		1	16
integrity (n=17)		7	10
flawed (n=16)		2	14
review and update (n=16)		3	13
alternative model (n=15)	2	1	12
independence (n=12)	1	2	9
electric heating (n=11)	1	1	9
reporting (n=9)	1	3	5
ventilation (n=9)	2		7
accountability (n=6)			6
fuel poverty (n=6)		2	4
thermal mass (n=5)		2	3
administration (n=4)			4
affordable warmth (n=4)		3	1
thermal imaging (n=4)	1	2	1
embodied energy (n=2)		2	
hard to treat (n=2)		1	1
windows (n=2)			2
improvements (n=1)			1
room in roof (n=1)			1

Table 4.3.2 - Frequency analysis of Keywords by public consultation data source

When disaggregated by the issue classification categories, a different keyword dominates each issue classification category: with calculation issues, the keyword ‘performance gap’; with assessment issues, the keyword ‘surveyor skills’; with reporting issues, the keyword ‘recommendations’; and with database issues, the keyword ‘database’ (see Table 4.3.3). Two keywords appear across all four issue classifications: benchmarking and district heating; although not amongst the most common keywords in any category, these two demonstrate a breadth to their nature.

Keyword (n=1066)	Calculation (n=319)	Assessment (n=402)	Reporting (n=321)	Database (n=24)
surveyor skills (n=208)		**202**	6	
recommendations (n=178)	23	26	**129**	
performance gap (n=139)	**100**	21	18	
metric (n=70)	36	5	29	
minimum standards (n=54)	1	13	40	
awareness of SAP (n=41)	4	2	35	
decarbonisation (n=32)	26	1	5	
traditional buildings (n=31)	22	9		
new technologies (n=26)	19	2	5	
QA procedures (n=24)		24		
benchmarking (n=23)	6	7	9	1
database (n=22)			2	**20**
quality assurance (n=21)	1	20		
district heating (n=19)	11	1	4	3
real data (n=19)	15	3	1	
conventions (n=17)	1	13	3	
integrity (n=17)		16	1	
flawed (n=16)	8	2	6	
review and update (n=16)	11		5	
alternative model (n=15)	11	1	3	
independence (n=12)		12		
electric heating (n=11)	9	2		
reporting (n=9)	1		8	
ventilation (n=9)	3	6		
accountability (n=6)		5	1	
fuel poverty (n=6)	2		4	
thermal mass (n=5)	5			
administration (n=4)			4	
affordable warmth (n=4)	1		3	
thermal imaging (n=4)		4		
embodied energy (n=2)	2			
hard to treat (n=2)	1	1		
windows (n=2)		2		
improvements (n=1)		1		
room in roof (n=1)		1		
Key				
cells in **RED** identify the keyword most common within the Issue Classification category				

Table 4.3.3 - Frequency analysis of Keywords by Issue Classification category

In Table 4.3.4, the 35 keywords are cross-referenced against the 18 broad themes. What emerges is that five of the keywords fall within at least two-thirds of the broad themes identified in this review: surveyor skills, recommendations, performance gap, metric, and traditional buildings. These are not only amongst the most common contributions identified with the three public consultations but also demonstrate that these issues are not just narrowly focussed. Another nine of the keywords fall with between half and two-thirds of the broad themes: minimum standards, decarbonisation, new technologies, benchmarking, database, district heating, alternative models, electric heating and ventilation.

Broad Theme > / Keyword	methodology (n=794)	modelling (n=725)	report (n=299)	improvements (n=289)	assessor (n=286)	occupancy (n=128)	built form (n=106)	conventions (n=88)	location (n=65)	heating (n=64)	fabric (n=56)	data collection (n=52)	data storage (n=33)	energy supply (n=29)	climate (n=26)	condition (n=19)	age dwelling (n=12)	ventilation (n=11)
surveyor skills	**20**	**17**	**20**	**20**	**206**	**3**	**18**	**7**	**4**		**5**					**5**	**5**	**2**
recommendations	**171**	**154**	**169**	**169**		**20**	**33**	**9**	**20**	**4**	**15**			**3**	**1**	**8**	**2**	
performance gap	**139**	**139**	**9**	**6**		**43**	**13**	**10**	**11**	**4**		**7**		**5**	**9**	**1**	**2**	
metric	**69**	**67**	**4**	**5**		**14**	**3**	**5**	**11**	**4**	**3**			**4**	**6**			
minimum standards	**51**	**46**	**51**	**51**		**1**	**2**		**2**					**1**		**3**		
awareness of SAP	40	24				4	1											
decarbonisation	**32**	**30**	**4**	**4**		**1**			**1**	**20**				**14**	**1**			
traditional buildings	**31**	**30**	**6**	**6**		**1**	**25**	**1**	**8**		**17**				**1**	**1**	**3**	
new technologies	**25**	**25**	**5**	**7**		**1**		**2**		**4**	**9**	**1**	**1**	**2**				
QA procedures	3	3	1	1	24			7										
benchmarking	**21**	**15**	**2**			**2**	**1**	**2**	**3**			**4**	**1**					
database	**12**	**9**				**5**			**1**	**1**		**19**	**21**		**1**			
quality assurance	11	10	3	3	20			20				1						
district heating	**19**	**19**	**6**	**6**		**6**				**15**		**3**	**3**		**2**			
real data	19	19				8						11	5		3			
conventions	17	15				1	3	15		1								
integrity	6	4	3	3	17			2			1							
flawed	16	16						1	2									
review and update	16	16	2	1		4		2										
alternative model	**15**	**15**	**1**	**1**		**6**						**2**	**1**		**2**			
independence	1	1	2	1	12	1												
electric heating	**11**	**11**	**1**	**1**		**1**		**1**	**1**	**11**								
reporting	9	7	7	1		3			1									
ventilation	**9**	**9**	**1**	**1**		**2**	**1**	**2**										**9**
accountability	3				6			1										
fuel poverty	6	6				1												
thermal mass	5	5					2				4							
administration	2	1						1				1	1					
affordable warmth	4	2																
thermal imaging	4	4	1	1								3						
embodied energy	2	2																
hard to treat	1						2											
windows	2	2					1				2							
improvements	1	1			1											1		
room in roof	1	1	1	1			1											

Key

Keywords in **RED** account fall within at least two-thirds of the 18 Broad Themes

Keywords in **YELLOW** fall within between half up to two-thirds of the 18 Broad Themes

Table 4.3.4 – Frequency analysis of Keywords cross-referenced by Broad Themes

4.4 Non-domestic Buildings

The contributions from the three public consultations were categorised as pertaining specifically to either domestic buildings or non-domestic buildings, or both (i.e. they were concerned with EPCs or the energy performance of buildings but did not explicitly reference either SBEM, or SAP or RdSAP, so could in principle be applied to equally to both types of building).

4.4.1 Thematic Analysis

When the frequency of the broad themes identified in the contributions categorised as pertaining to 'non-domestic' and 'both' domestic and non-domestic buildings are sorted by the source of the contribution, what emerges is the dominance of the contributions from the PRS consultation (see Table 4.4.1): 976 of the 1568 responses (i.e. 62%) came from the PRS consultation. The same dominance of the PRS contributions is seen when the frequency of the assigned keywords is sorted by the source of the contribution (see Table 4.4.2): 290 of the 501 contributions (i.e. 58%) came from the PRS consultation.

	LHEES		SEEP		PRS		
Broad Theme	**Both**	**Non-dom**	**Both**	**Non-dom**	**Both**	**Non-dom**	**TOTAL**
Methodology	26	6	129	18	259	4	442
Modelling	22	6	121	14	247	3	413
Report	1	0	29	5	100	1	136
Improvements	3	0	28	0	99	1	131
Assessor	0	1	23	0	72	0	96
Occupancy	10	0	34	1	28	1	74
Built Form	0	0	2	2	39	0	43
Convention	0	0	8	0	33	0	41
Heating	7	0	18	0	15	0	40
Data Collection	10	4	12	3	7	0	36
Location	0	0	4	3	17	0	24
Fabric	0	0	4	1	17	0	22
Climate	5	0	4	1	11	0	21
Data Storage & Retrieval	5	3	3	0	5	0	16
Energy Supply	0	0	8	0	5	0	13
Condition	1	0	3	0	8	0	12
Age	0	0	2	1	1	0	4
Ventilation	0	0	1	0	3	0	4
TOTAL	90	20	433	49	966	10	1568

Table 4.4.1: Frequency of Broad theme contributions by Consultation (non-domestic only and both sectors)

Keyword	LHEES		SEEP		PRS		TOTAL
	Both	Non-dom	Both	Non-dom	Both	Non-dom	
recommendations	2	0	13	2	78	1	96
performance gap	3	0	55	3	31	1	93
quality assurance	0	0	17	0	48	0	65
Metric	1	0	8	0	35	0	44
benchmarking	0	0	8	12	1	2	23
decarbonisation	1	0	13	0	9	0	23
traditional buildings	0	0	2	0	19	0	21
awareness of SAP	0	0	8	0	12	0	20
real data	8	4	2	1	2	0	17
flawed	0	0	2	0	13	0	15
review & update	0	0	2	1	10	0	13
district heating	8	0	3	0	1	0	12
minimum standards	0	0	2	0	6	0	8
database	2	0	2	0	4	0	8
alternative model	0	2	0	0	4	0	6
surveyor skills	0	1	5	0	0	0	6
electric heating	1	0	1	0	4	0	6
new technologies	0	0	5	1	0	0	6
reporting	1	0	0	0	2	0	3
thermal imaging	1	0	2	0	0	0	3
administration	0	0	0	0	3	0	3
ventilation	0	0	0	0	2	0	2
thermal mass	0	0	2	0	0	0	2
embodied energy	0	0	2	0	0	0	2
hard to treat	0	0	0	0	1	0	1
room in roof	0	0	0	0	1	0	1
affordable warmth	0	0	1	0	0	0	1
fuel poverty	0	0	1	0	0	0	1
Total	28	7	156	20	286	4	501

Table 4.4.2: Frequency of Keywords by Consultation (non-domestic only and both sectors)

Non-domestic specific issues with regard to SBEM and EPCs were primarily raised via the responses to the SEEP and LHEES consultations, and were at a significantly lower level than the comments regarding domestic buildings. This in part is not surprising: the LHEES consultation was primarily focussed on local heat networks, and while the SEEP consultation sought discussion on both domestic and non-domestic buildings, there were no specific questions about non-domestic buildings so most of the contributions were categorised as being of concern to 'both' domestic and non-domestic buildings. The responses relating to the PRS consultation (by far, the most numerous overall) were primarily concerned with domestic building issues. Where contributions were identified as pertaining to 'both' the domestic and non-domestic buildings (e.g. concerned with EPCs or the energy performance of buildings but did not explicitly reference either SBEM or SAP or RdSAP), the decision was taken to include these within the discussions within the rest of this report where appropriate.

Only 31 contributions were categorised as pertaining specifically to the non-domestic sector, and represented a very small proportion (2.9%) of the overall 1066 contributions. These 31 non-domestic specific building contributions fell across 13 of the 18 broad themes.[44] Most of the non-domestic contributions were concerned with either methodological or modelling issues, or both. The overall frequency of the broad theme results are summarised by the public consultation they came from in Table 4.4.3 below.

Broad theme	LHEES	SEEP	PRS	TOTAL
Methodology	**6**	**18**	**4**	**28**
Modelling	**6**	**14**	**3**	**23**
Data Collection	4	3	0	7
Report	0	5	1	6
Data Storage & Retrieval	3	0	0	3
Location	0	3	0	3
Built Form	0	2	0	2
Occupancy	0	1	1	2
Age	0	1	0	1
Fabric	0	1	0	1
Improvements	0	0	1	1
Assessor	1	0	0	1
Climate	0	1	0	1
TOTAL	20	49	10	79

Table 4.4.3: Frequency of Broad theme contribution by Consultation (non-domestic only)

4.5 Comment on the Thematic Analysis

Through the frequency analysis, the use of the pivot tables, and the application of the broad theme descriptors, and keywords, the thematic analysis allowed 1066 diverse individual comments to be collated in a manner to highlight common themes and concerns, and to gauge the strength of these concerns through the frequency they were expressed in the public consultations. Some of this frequency reflected specific questions included within the consultation exercises.

What emerges is overlapping broad theme and keyword groupings touching a large number of the responses to the public consultations:

- **SAP, RdSAP and SBEM metric-related issues**: performance gap, metric, methodology and modelling
- **Assessor-related issues**: assessor, surveyor skills, quality assurance procedures, quality assurance, integrity, and independence

[44] A contribution could be assigned to more than one theme

- **EPC reporting and recommendation-related issues:** reporting, recommendations, minimum standards, improvements, methodology, and modelling
- **Traditional Buildings-related issues**: traditional buildings, methodology, modelling, built form, and fabric

A separate analysis was carried out on the non-domestic building-related contributions. The small number of contributions specifically identified as pertaining to non-domestic buildings where overwhelmed by the concerns for domestic dwellings arising from the responses to the PRS consultation.
At a lower level of response, keywords of a more technical nature that touch a number of broad themes also emerge:

- decarbonisation
- new technologies
- benchmarking
- database
- district heating
- ventilation
- electric heating

This ‘bottom-up’ approach was used to identify topic areas and technical issues to be explored in more detail for further consideration through presentations, discussion and deliberation at the workshops. The shaping of the workshop topics and issues is discussed in the next section.

5. Identification of Issues, Workshops and Additional Modelling

5.1 Identification of topics and technical issues

In Section 4, the thematic analysis identified four overarching topic areas that crossed over multiple broad themes and keywords. A fifth overarching topic, i.e. non-domestic buildings, was added here to these four: the relatively few responses concerned specifically with non-domestic building issues meant they were obscured by domestic building concerns, although non-domestic building concerns also crossed over multiple broad themes and keywords.

Along with these overarching topics, a number of more technical issues also emerged.

These were reduced to four specific issues here, as one of technical issues was outside the scope of this review (i.e. decarbonisation) and several technical issues became subsumed within the overarching topics (i.e. benchmarking, new technologies, electric heating). Two technical issues (i.e. rooms in the roof, and measuring windows) were added based on the authors' experience. The 5 overarching topics and 4 specific technical issues are presented graphically in Figure 5.1.1 below.

Figure 5.1.1: Overarching Topics and Technical issues

Each of these overarching topics and technical issues are explored in more detail in this section with regard to identifying specific concerns within them.

5.2 Traditional buildings

5.2.1 What is traditional?

It would appear many people have a view on what is a 'traditional' building, and that these views encompass a wide diversity of opinions and constructions. The thematic analysis categorised 85 responses from within the 'built form' theme as pertaining to traditional buildings[45], by combining the contributions described as 'traditional', 'older' and 'pre-1919' (see Table 5.2.1)

Broad theme: Built Form	Number of contributions
traditional	72
older	12
rooms in roof	8
non-traditional	4
hard to treat	3
Scottish housing stock	2
size	1
whole building	1
pre-1919	1
pre-1940	1
masonry	1
Total	106

Table 5.2.1: Frequency analysis of descriptors within 'Built Form' theme

5.2.2 Identifying the Issues

The starting point for examining the issue of traditional buildings within SAP, RdSAP and SBEM calculation methodologies and the production of EPCs is a public perception that the process is not attuned to the needs of traditional dwellings: for example;

"The EPC is not sensitive to the nature of these houses and imposes one standard across all areas and housing types".[46]

This public perception is evident when the traditional building responses are examined in more detail.

The nature of many of the comments revolve around the methodologies not taking into account some aspect of a traditional building sufficiently in the calculation, for example, the use of default data results in inaccurate results and inappropriate recommendations on the EPC. However, some of the comments conflate a number of issues: it is not that SAP, RdSAP or SBEM did not take account of the nature of

[45] During the initial categorisation of public responses to the consultation documents all mentions of the words 'historic' or 'listed' with regards to buildings' built form were classified as 'traditional' within this category

[46] Taken from response 36838773 available at https://consult.gov.scot/better-homes-division/energy-efficiency-programme/consultation/published_select_respondent?_b_index=120

traditional buildings but that the respondent was unhappy with the results or the improvement recommendations, or that they considered they had done everything to improve their property and it still did not comply with the proposed minimum SAP (energy efficiency) standard, for example;

"We spent in excess of £20,000 fully insulating a traditional granite 1.5 story farmhouse with environmentally friendly products (wool insulation & Icynene) and installed a wood burning stove with back boiler for radiators and oil back up boiler (no mains gas, wood pellets not viable, electricity supply not reliable enough to install air source heat pump) at further cost and achieved a low E in the EPC. There is obviously a huge glitch in the software calculation"[47]

These issues need to be disentangled to discern the actions that would enhance EPCs in Scotland as we go forward.

The 85 responses pertaining to 'traditional buildings' were spread across 18 keywords, with almost a complete overlap with the methodology and modelling broad themes (see Table 5.2.2 below). Cross-referencing the keywords against the methodology and modelling broad themes identifies the more specific nature of the concerns. The three most common issues were:

- the use of default values in the calculation and assessment of SAP, RdSAP and SBEM and their reporting on the EPCs;
- the reporting of the results and recommendations on the EPC which are the determined within RdSAP by Appendix T of the SAP methodology; and,
- the accuracy of the results produced for traditional buildings.

Overwhelmingly, the responses on traditional buildings came from the private rented sector consultation.

These 'traditional building' concerns fall across several of the overarching topics.

[47] Taken from response 471251986, available at https://consult.gov.scot/better-homes-division/energy-efficiency-programme/consultation/published_select_respondent?_b_index=120

Keyword	Broad theme: Methodology							Broad theme: Modelling							
	Appendix T (n=31)	Metric (n=20)	Defaults (n=17)	PCDB (n=4)	Thermal mass (n=3)	New tech. (n=2)	Not classified[48] (n=8)	Defaults (n=32)	Accuracy (n=25)	U-values (n=7)	Metric (n=4)	Min standards (n=3)	Thermal mass (n=3)	Real data (n=1)	Not classified (n=10)
recommendations (n=28)	22	1		3		2		21	5			1			1
traditional buildings (n=24)	2	9	11	1	1			3	10	7	1		1	1	1
surveyor skills (n=14)	5	1					8	4	2						8
performance gap (n=8)		5	3						8						
metric (n=3)		3									3				
minimum standards (n=2)	2							1				1			
thermal mass (n=2)					2								2		
benchmarking (n=1)		1										1			
conventions (n=1)			1					1							
ventilation (n=1)			1					1							
windows (n=1)			1					1							
Total	31	20	17	4	3	2	8[49]								

Table 5.2.2: Frequency of traditional building contributions broken down by Methodology and Modelling themes

[48] Not classified in this broad theme

5.3 EPC reporting and recommendations

5.3.1 Current Scottish Domestic Sector EPC Format

The Scottish domestic sector[50] EPC presents an energy performance assessment of a property in terms of its energy efficiency rating (i.e. the SAP score and its banding) (see Figure 5.3.1) and its environmental impact rating (see Figure 5.3.2).

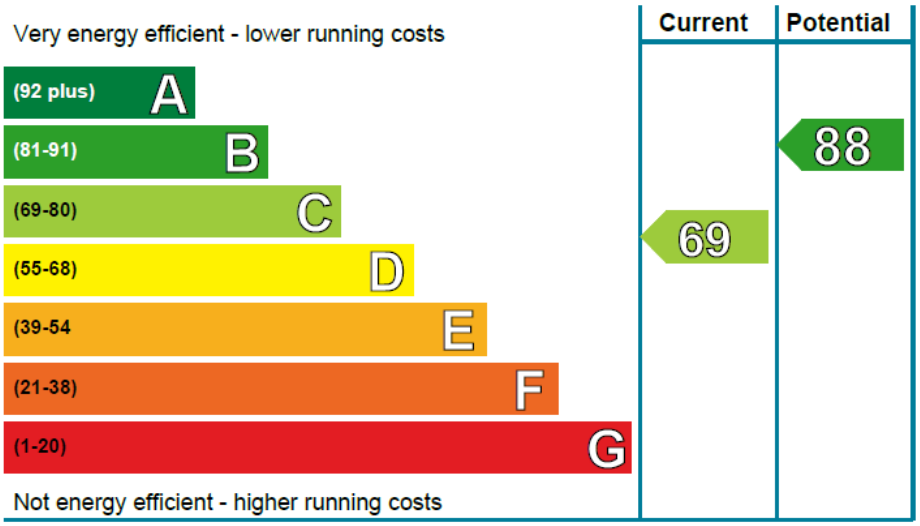

Figure 5.3.1 – The Energy Efficiency Rating graphic showing the A-G banding with their respective range of SAP scores, the current SAP score and banding of the property assessed, and its potential SAP score and banding if all recommendations are implemented

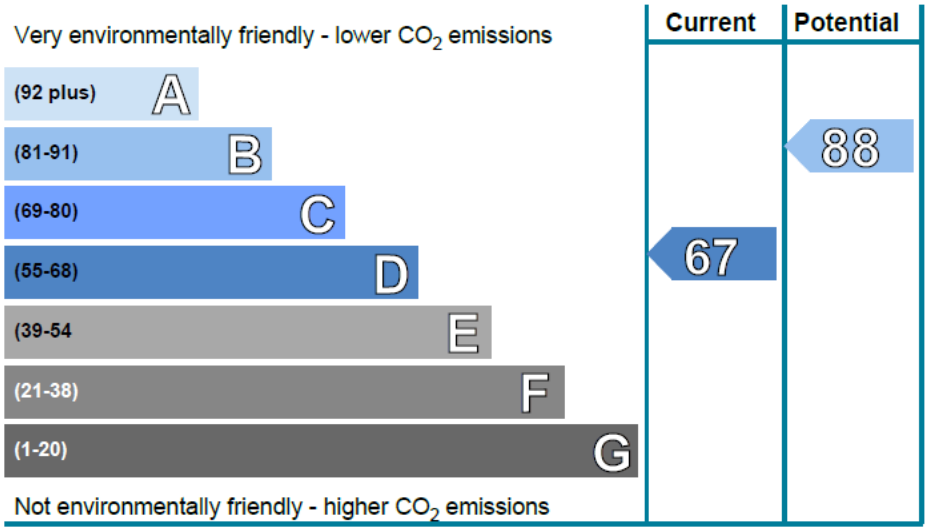

Figure 5.3.2 – The Environmental Impact Rating (EIR) graphic showing the A-G banding with their respective range of EIR scores, the current EIR score and banding of the property, and its potential EIR score and banding if all recommendations are implemented

[50] Non-domestic sector buildings are considered elsewhere in this report.

In terms of the proposals for the private rented sector, it is the energy efficiency rating that is being used as the basis of the standard[51], and not the environmental impact rating.

The EPC also presents a list of technically feasible 'Recommended measures' derived from the assessment of a property, relevant to that property, that would improve both the energy efficiency rating and the environmental impact rating of the assessed dwelling (see Figure 5.3.3).

Recommended measures		Indicative cost	Typical saving per year	Rating after improvement		Green Deal
				Energy	Environment	
1	Floor insulation (suspended floor)	£800 - £1,200	£57	C 71	C 70	✓
2	Low energy lighting for all fixed outlets	£40	£25	C 72	C 71	
3	Replace boiler with new condensing boiler	£2,200 - £3,000	£98	C 76	C 76	✓
4	Solar water heating	£4,000 - £6,000	£33	C 78	C 78	✓
5	Solar photovoltaic panels, 2.5 kWp	£5,000 - £8,000	£256	B 88	B 88	✓

Figure 5.3.3 - An example of the "Recommended measures" report on an EPC demonstrating their cumulative, sequential impact on the property assessed.

The recommended measures that appear on the EPC are selected automatically by the assessment software; for domestic building assessments, based upon the building data input and assigned based on a method described under Appendix T of the SAP methodology[52]. While assessors may de-select measures based on site or building related issues not captured in the standard data for RdSAP, they cannot add measures to the list of recommendations.

5.3.2 Identifying the issues

The starting point here was the expressed dissatisfaction seen in many contributions with what is currently included in the EPC recommendations, or how it is presented, and looking forward, what should be included in the recommendations / report. These concerns are reflected in the following quotes:

"*Introduce a practical assessment of the properties to be adopted alongside the EPC which will address the practical issues of whether it makes sense to carry out the*

[51] The energy efficiency rating is already used as the basis of the EESSH obligation with social housing landlords.
[52] Set out in pp162-171 of the SAP 2012 methodology, available at https://www.bre.co.uk/filelibrary/SAP/2012/SAP-2012_9-92.pdf

works and whether they will cause future issues of condensation etc. in the property."[53]

"*understand that RdSAP/EPC system links information from the survey to a database of costs of measures. However, these do not relate to the reality found during insulation installation projects for traditional buildings and, according to the database, some costs e.g. solid wall insulation cost the same if you are in a 5 room or 6 room house, which we feel cannot be correct.*"[54]

An assessment of the lowest cost approach to bring the property up to standard appears to be a useful starting point, but it will be necessary for the assessors to be sufficiently well trained to understand what is and is not appropriate for properties of different construction types so that their recommendations are practical, relevant and safe, rather than, as all too often, simply formulaic."[55]

Contributions relating to the broad themes of 'Reporting' (n=299) and 'Improvements' (n=289) extended across 19 of the Keyword categories, however, by far the most frequent issues with EPCs and how 'Improvements' are described were within the contributions relating to 'recommendations' and 'minimum standards' (see Table 5.3.1). The pivot table analysis set out in Appendix A.4 indicates that the overwhelming majority of these contributions (85%) came via the public responses to the PRS consultation and focussed on domestic sector; only one of the 289 responses on 'Improvements' related exclusively to the non-domestic buildings.

Comments related to 'minimum standards' were on the whole directed at suggesting how the EPC could be used as a means to communicate the ways in which dwellings could be improved to meet the minimum standards:

"*the assessment should set out the lowest cost package of measures required to bring the property up to standard.*"[56]

"*the assessment should set out the package of measures to meet an energy efficiency rating of E, and separately of D, from the property's current rating.*"[57]

This is not surprising as the format of the PRS consultation specifically invited respondents to offer opinions on how the EPC could be utilised to provide such information to occupants[58].

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[53] Response 8314891 taken from https://consult.gov.scot/better-homes-division/energy-efficiency-programme/consultation/published_select_respondent
[54] Response 513682743 taken from https://consult.gov.scot/better-homes-division/energy-efficiency-programme/consultation/published_select_respondent
[55] Response 19115688 taken from https://consult.gov.scot/better-homes-division/energy-efficiency-programme/consultation/published_select_respondent
[56] Response 447620038 taken from https://consult.gov.scot/better-homes-division/energy-efficiency-programme/consultation/published_select_respondent
[57] Response 742030389 taken from https://consult.gov.scot/better-homes-division/energy-efficiency-programme/consultation/published_select_respondent
[58] There were 55 comments on the subject of minimum standards of which 53 came from the PRS consultation. The two other comments were found in the SEEP consultation and both back-referenced

Keyword	Broad themes	
	Reporting	Improvements
recommendations	**180**	**180**
minimum standards	**52**	**52**
performance gap	9	6
quality assurance	8	7
reporting	7	1
surveyor skills	7	7
traditional buildings	7	7
district heating	6	6
new technologies	5	7
decarbonisation	4	4
metric	4	5
benchmarking	2	-
review and update	2	1
alternative model	1	1
electric heating	1	1
flawed	1	1
hard to treat	1	1
room in roof	1	1
thermal imaging	1	1
Total	**299**	**289**

Table 5.3.1 - Frequency analysis on response terms under Reporting and Improvements themes

Six particular issues with regard to EPC reporting and recommendations were identified through the analysis:

- Appendix T
- the Product Characteristics Database (PCDB)
- meeting minimum standards
- recognising new technologies
- the RdSAP metric
- the format of the recommended measures table on the EPC

The frequency analysis relating to these issues are set out in Table 5.3.2 below.

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the 'minimum standards assessment' question raised in the PRS consultation.

Issue	Assessment	Calculation	Reporting	Total
Appendix T Method	40	11	99	150
Format Recommendations Table	10	22	25	57
Product Characteristics Database	3	7	40	50
Minimum Standards	10	1	39	50
Metric	14	10	25	49
New Technologies	1	4	4	9
total	78	55	232	365

Table 5.3.2: Frequency analysis of EPC reporting and recommendation issues (by issue classification)

The role of the assessor within the reporting and recommendations process is not well understood. While the recommendations are based on the information collected by the assessor and entered into the respective program; the assessor has a role in providing reliable and correct data in accordance with the conventions. Beyond that, the assessor is somewhat irrelevant to the process: the selection of the recommendations, the determination of the costs of the measures for domestic buildings, and the calculation of the savings on fuel bills or the return on the investment are governed by Appendix T and the PCDB – two components of the software currently outwith the control of the assessor.

The PCDB[59] which provides the reference values used in the calculations of the location-specific fuel bills on the EPC is regularly reviewed and revised as necessary. Product specific information (e.g. new boilers and boiler efficiencies) are updated monthly; localised fuel prices are reviewed 6-monthly. By contrast, the base costs used to calculate the 'Indicative costs' of the 'Recommended measures' table do not appear to have been updated since 2012[60]. It is understandable that contributions questioned the validity of the improvement measure costs published on the EPC or their rates of return, or suggested that this could be an area where users could input their own prices. The need for, and added costs of requisite building warrants and / or planning applications are not factored into the costs presented on the EPC; occupants need to be made aware of such additions when considering the value of investment in energy efficiency.

As the proposed minimum standards are rolled out across the private sector, the cost of meeting these standards is likely to be the focus of more and more attention amongst landlords and owners. The analysis prepared for the Scottish Government on developing the regulation of energy efficiency of private sector housing explicitly

[59] https://www.ncm-pcdb.org.uk/sap/searchpod.jsp?id=17
[60] See http://www.gov.scot/Resource/0048/00488551.pdf

examined the lowest cost associated with meeting various energy efficiency standards for 355 archetypes[61]; the EPC is currently not designed in a way to replicate this type of approach, nor the software designed to calculate the costs in such a manner.

The development of new technology is outpacing the ability of the modelling to capture its impact either in terms of energy efficiency or on the running costs for occupants. RdSAP, in particular, is very poor in the way that new technologies are handled.

The recommendations on the EPC are not customised to the occupant, nor are they produced in way that encourages selective decision making, picking and choosing single improvements on an informed basis. The existing EPC reports an aggregated EPC rating, improving as each measure is modelled in sequence, which is not useful when looking at the impact of specific measures. The appropriateness of recommended improvements needs to be highlighted and occupants directed to seek professional help in assessing the risks:

"*the EPC assessment should be used as part of a minimum standards assessment and that the methodology is utilised as part of this*"[62]

"*the Standard Assessment Procedure (SAP) methodology cannot substitute for a design approach to building improvements and any methodology which is hard coded into SAP runs the danger of promoting inappropriate interventions which harm the building fabric or historic value of traditional buildings.*"[63]

If EPC reports are to offer more-tailored recommendations to building owners, or possibly use real data in the improvement cost calculations and the estimation of potential savings, there would need to be major changes to both the assessment software and the EPC format.

[61] ibid
[62] Response 433809798 taken from https://consult.gov.scot/better-homes-division/energy-efficiency-programme/consultation/published_select_respondent
[63] Response 816313150 taken from https://consult.gov.scot/better-homes-division/energy-efficiency-programme/consultation/published_select_respondent

5.4 SAP, RdSAP and the EPC Metrics

5.4.1 Measuring Energy Efficiency

The 'energy efficiency' of a property can be expressed in many ways: the SAP score is one way. Importantly, SAP is an energy cost index: it combines energy consumption, energy efficiency and fuel prices into a single number. In simple terms, it is an expression of the cost to achieve a specific space heating regime, and provide adequate hot water and sufficient lighting, divided by the dwelling's total floor area (i.e. £/m^2). It was designed to be insensitive to floor area so that big houses could be compared with small flats. It is an asset rating: it is about the property, and uses standardised assumptions on the occupants and their use of fuel. It is not about the actual occupants or their use of the property; and these can be decidedly different from the assumptions.

'Miles per gallon' is a commonly understood metric associated with the energy efficiency of a motor car; the same cannot be said about SAP. As a measure of energy efficiency, improving the SAP score will occur if the improvements impact on a part of the energy system providing the amenity of space heating, water heating and/or lighting. Other actions that may reduce energy consumption (e.g. using microwave energy over a thermal appliance for cooking purposes or swapping to a A+++ fridge freezer from an older 'B' rated appliance) may reduce energy consumption and improve energy efficiency, but are outside the scope of the EPC metric.

Within SAP and RdSAP, all fuels have an associated cost. The calculations utilise nationally derived fuel costs assigned to them regardless of what the building occupant is actually paying[64]. SAP and RdSAP are not biased against rural areas as such, but if a building is reliant on a fuel other than mains gas[65] (e.g. being off the gas grid), then it will result in a lower SAP score even if everything else about the building was identical and the fuel was sourced for free by the occupants.

[64] For SAP and RdSAP these prices are set out in Table 11 of the SAP 2012 manual, available at https://www.bre.co.uk/filelibrary/SAP/2012/SAP-2012_9-92.pdf

[65] Mains gas is the cheapest fuel within SAP / RdSAP, though there some areas with LPG and LNG networks governed by Special Condition 18, whereby the price of LPG or LNG on the local network is tied to the average mains gas price.

5.4.2 Identifying the Issues

The starting point here is the very evident dichotomy within the public perception of SAP, RdSAP and the EPC metrics as expressed in the following two quotes:

"*Landlords, tenants and householders are becoming more familiar with the EPC, and it is already used in the Tenant Information Packs, marketing materials, and required at change of tenancy. The A-G scale provides a simple understanding of the energy performance of the property as it compares with other properties in the UK that is readily accessible. A literature review from ClimateXChange found that members of the public thought the A-G scale was a 'key strength' of the EPC as it is 'easily understandable'.*"[66]

"*As a tool for the mass market RdSAP/EPC is not a good product. At the moment it is a product that can only be understood by trained assessors and even then they often cannot explain the output.*"[67]

Contributions relating to the values and metrics contained within the EPC were on the whole split between the broad themes of 'Methodology' (n=355) and 'Modelling' (n=124) (see Table 5.4.1). It can be seen in the pivot table analysis in Appendix A.4, that the responses within the 'Methodology' theme were sourced primarily from the PRS consultation responses (65%) with only 4% coming from the LHEES consultation responses, and 30% from SEEP. With regard to the 'Modelling' theme, more were sourced from the LHEES responses (12%) and less from the SEEP responses (19%), but the PRS consultation responses were still the main source of the responses (69%).

[66] Response 377886956 taken from https://consult.gov.scot/better-homes-division/energy-efficiency-programme/consultation/published_select_respondent

[67] Response 385144840 taken from https://consult.gov.scot/better-homes-division/energy-efficiency-programme/consultation/published_select_respondent

Keyword	Broad themes	
	Methodology 'metric'	Modelling 'metric'
performance gap	**84**	**18**
metric	**66**	**33**
awareness of SAP	**40**	**19**
recommendations	27	4
decarbonisation	18	3
flawed	16	10
minimum standards	12	1
quality assurance	12	-
review and update	12	2
traditional buildings	11	2
benchmarking	10	3
electric heating	10	1
fuel poverty	6	2
district heating	5	4
real data	4	4
reporting	4	4
affordable warmth	3	1
surveyor skills	3	-
ventilation	3	1
database	2	6
administration	1	-
alternative model	1	4
conventions	1	1
embodied energy	1	-
hard to treat	1	-
room in roof	1	-
thermal imaging	1	1
Grand Total	**355**	**124**

Table 5.4.1 - Frequency analysis on response terms for metric focussed issues for Methodology and Modelling broad themes by Keyword

This analysis identified 3 particular issues with regard to the SAP and RdSAP metrics:

- metrics and asset ratings
- the use of real data
- occupancy factors

These are set out in Table 5.4.2 below.

Issue	Calculation	Assessment	Reporting	Database	Total
Metrics / Asset Ratings	168	57	128	2	355
Real Data	40	16	45	9	110
Occupancy Factors	46	10	50	0	106
Total	254	83	223	11	571

Table 5.4.2: Frequency Analysis of SAP and RdSAP-related metric issues by Issue Classification

The concept of a rating scale is easy to understand: the closer the letter is to 'A', the better, and this has received public support. From the total of 73 contributions of the total of 1066 from the three public consultations that were categorised as 'positive' with regard to SAP, RdSAP, SBEM, and EPCs, 62 (i.e. 85%) of them were related to 'metrics' within the methodology theme.

The rest of the EPC is perhaps less accessible and understood. The EPC appears to the average lay person as a very technical document. While the public are mostly aware of the EPC in relation to selling or renting a property, if the purpose of the EPC is to engage with the population in order to encourage a greater interest in energy efficiency and the impact that this may have from a fuel cost, energy efficiency, or environmental viewpoint, the data presented needs to be more user friendly for the householder, e.g. values such as 'Primary Energy Indicator' are just not easy to understand.

Robust reasons underpin the choice of metric for assessing the energy performance of a building: cost was seen as providing a consistent method to account for the relationship between price and delivered energy efficiency. However, if the policy focus is on emissions, then the use of fuel cost rather than kWh or CO_2 emissions penalises low carbon fuels when compared against lower cost but higher carbon fuels, with possible negative outcomes for climate change e.g. comparing biomass against mains gas or kerosene. If the policy intention is to use EPCs to promote a lower carbon future, then behaviour change is an important factor as this impacts on actual energy use, and therefore emissions in the real world, not modelled energy use; and not just space and water heating and lighting, but all energy use in the building:

"*emissions from domestic and non-domestic buildings respectively must rely heavily on decarbonising the supply side … applying to heat only … modest targets are again for regulated heat when a significant proportion of demand is for unregulated electricity to power white goods, electronic devices, etc.*"[68]

[68] Response 114630764 https://consult.gov.scot/energy-and-climate-change-directorate/scotlands-energy-efficiency-programme/consultation/published_select_respondent

The EPC itself actually reflects two different metrics at work. The SAP score is based on standardised fuel costs, heating patterns, and occupancy assumptions for a single climatic zone in the UK[69]. The energy running costs set out on the EPC are derived from the PCDB (see Appendix A.7) and are updated every 6 months and utilise postcode-based climatic data (i.e. external temperatures, wind speed, and solar radiation on horizontal surfaces). Relocating a dwelling anywhere in Scotland will not change the calculated SAP score; however, the calculated fuel costs, energy demand, emissions, primary energy use, and potential savings, will all change on the EPC.

"*We would like to give the energy assessors a 'tool' to extend the EPC to include an occupancy evaluation, thus providing the asset rating (EPC), and overlaying this with the occupation details to create 'tailored' recommendations for the tenants/landlords and the property.*"[70]

The Green Deal Advice Report set a precedent for using the EPC-derived data to prepare energy advice reports tailored to individual householders, their circumstances, their use of the dwelling, heating and other appliances, and what they were actually paying for fuel: the asset rating remained unchanged, but the underlying data was imported into a separate program. The ensuing recommendations were very different from those on the EPC. Such an individualised assessment does not allow for comparison with other properties on a like-for-like basis.

Using real data over time could improve our understanding of how occupants actually use their properties and also how properties respond to being used in non-standard ways. In addition, half hourly metering data from smart meters could be utilised for the purposes of better understanding how energy is used over a 24 hour period and throughout the year. If real cost data is used for measures, then this could also account for the embodied energy of the measure, to allow for a more comprehensive environmental impact assessment. These issues are currently beyond the existing scope of the SAP, RdSAP and SBEM metrics.

[69] The East Pennine region is used as it is considered to be the UK mean average climatic zone. All Scottish climatic zones are colder and windier.
[70] Response 847124774 taken from https://consult.gov.scot/better-homes-division/energy-efficiency-programme/consultation/published_select_respondent

5.5 Non-domestic Buildings

5.5.1 Different requirements from domestic dwellings

Non-domestic buildings were separated out from the examination of either domestic building-related contributions, or those that could pertain to both domestic and non-domestic buildings. Non-domestic buildings have a separate assessment methodology and software, and their EPCs have a different format.

The rating scale of G (very poor) to A+ (excellent) mirrors that seen for domestic dwellings, but the basis of the Building Energy Performance Rating is an assessment of the kg of CO_2 per m^2 per year emitted from the building, that is, more akin to the Environmental Impact Rating on the domestic building EPC than the SAP-based energy efficiency rating (see Figure 5.5.1).

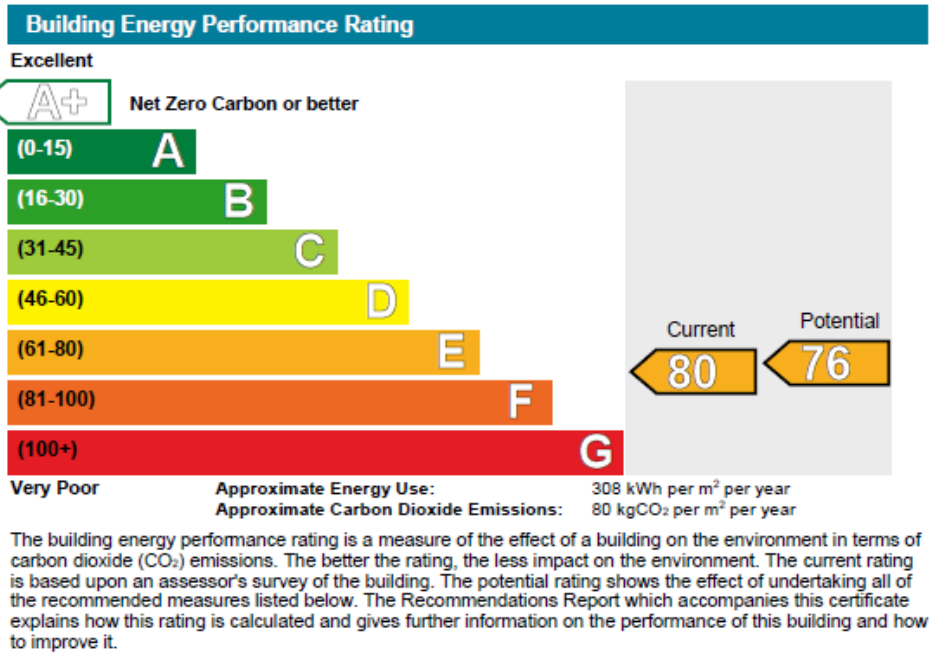

Figure 5.5.1 – Building Energy Performance Rating graphic showing the A-G banding with their respective range of kg of CO_2 per m^2 per year values , the BEPR score of the property assessed, and its potential BEPR score and banding if all recommendations are implemented.

The recommendations for non-domestic buildings are banded by their payback period (short, medium and long term) with indicative potential impacts rather than the more quantified savings seen on the domestic EPC (see Figure 5.5.2).

Recommended measures with a short payback period (less than 3 years)

Recommendations (short payback)	Potential Impact
Consider replacing T8 lamps with retrofit T5 conversion kit.	MEDIUM
Add optimum start/stop to the heating system.	MEDIUM
The default heat generator efficiency is chosen. It is recommended that the heat generator system be investigated to gain an understanding of its efficiency and possible improvements.	MEDIUM
Some walls have uninsulated cavities - introduce cavity wall insulation.	MEDIUM
Some windows have high U-values - consider installing secondary glazing.	MEDIUM
Add weather compensation controls to heating system.	MEDIUM

Recommended measures with a medium payback period (3 to 7 years)

Recommendations (medium payback)	Potential Impact
Add local time control to heating system.	LOW
Consider replacing heating boiler plant with a condensing type.	HIGH
Carry out a pressure test, identify and treat identified air leakage. Enter result in EPC calculation.	MEDIUM
Improve insulation on HWS storage.	LOW
Some glazing is poorly insulated. Replace/improve glazing and/or frames.	MEDIUM

Recommended measures with a long payback period (more than 7 years)

Recommendations (long payback)	Potential Impact
Consider installing building mounted wind turbine(s).	LOW
Consider installing solar water heating.	LOW
Consider installing PV.	LOW

Figure 5.5.2 - An example of the "Recommended measures" report on a non-domestic EPC demonstrating the separation of improvements into short, medium and long term payback, as well as the indicative potential impact for the property assessed.

There is considerably greater diversity in terms of size and purpose, as well as the uses within they are put to, than would be expected from houses. The energy demands and energy profiles within non-domestic buildings may be significantly different from that found in housing: space heating may not be particularly important compared to the needs for lighting, process and motive energy.

5.5.2 Identifying the Issues

When examined by the Keywords, the non-domestic specific contributions extended across only 8 of the 35 keywords. Almost half of the non-domestic contributions (14 of the 31) were concerned with benchmarking with the remaining 17 contributions spread across the other 7 keywords (see Table 5.5.2).

Keyword	LHEES	PRS	SEEP	TOTAL
benchmarking	0	2	12	14
real data	4	0	1	5
performance gap	0	1	3	4
recommendations	0	1	2	3
alternative model	2	0	0	2
surveyor skills	1	0	0	1
new technologies	0	0	1	1
review & update	0	0	1	1
Total	7	4	20	31

Table 5.5.2: Frequency of Keywords by Consultation (non-domestic only)

For the non-domestic specific issues, the greatest concern was with benchmarking, and this concern was spread across all three issue classifications (see Table 5.5.3). In total, eight issues were identified.

Keywords	Calculation	Assessment	Reporting	Total
Benchmarking	3	5	6	14
Real data	4	1	0	5
Performance gap	3	0	1	4
Recommendations	0	1	2	3
Alternative models	2	0	0	2
Surveyor skills	0	1	0	1
New Technologies	1	0	1	1
Review and Update	13	8	10	31

Table 5.5.3: Summary of keywords by Issue Classification (non-domestic only)

Benchmarking requires availability of energy consumption data and can then be used to prioritise measures/actions. Non-domestic buildings are not as homogenous as domestic dwellings; therefore it can be difficult to make comparisons between buildings used in different non-domestic sectors. The barriers to energy efficient retrofits (e.g. insulation) are more significant than for dwellings. A number of the contributions signposted to recent publications and methodologies from other countries. A preference was indicated for operational ratings rather than asset ratings and a suggestion made for funding of longer-terms measures for older buildings. Reference was also made to two UK government initiatives: the Carbon Reduction Commitment[71] and Energy Savings Opportunities Scheme[72].

[71] The initial Carbon Reduction Commitment has since evolved into the CRC Energy Efficiency scheme which, after the March 2016 Budget, will close after the 2018/19 compliance year. See https://www.gov.uk/government/collections/crc-energy-efficiency-scheme

[72] The Energy Savings Opportunities Scheme (ESOS) is a mandatory assessment scheme for UK organisations that meet the qualifying criteria managed by the UK Environment Agency. It is intended to increase awareness of the energy consumption to make it easier for businesses to take action. https://www.gov.uk/guidance/energy-savings-opportunity-scheme-esos

In Scotland, some larger non-domestic buildings[73] are already required to display an EPC. These are asset ratings produced via SBEM or other approved dynamic simulation models. These requirements are different from than the rest of the UK, where there are obligations to have Display Energy Certificates (DECs) on display in non-domestic buildings with a floor area of 250m^2 or more. The significant difference is that DECs are based on the operational performance of the building, comparing actual measured energy of the building over the past year with a typical building of the same type.

Collecting operational data would assist in benchmarking a building's actual energy performance, and Scotland is moving in that direction. Under Section 63 of the Climate Change (Scotland) Act[74], from September 2016, the owners of non-domestic buildings of more than 1000m^2 are required to "assess and set out action to improve the emissions and energy performance of their buildings where offered for sale or for rental to a new tenant. The owner must then either improve the building within a specified period or report annually on its actual energy use, until such time as he/she has completed improvements."[75] The annual report is to be via a DEC. Both the action plans and / or the DECs are to be lodged on the Scottish register.

It is difficult to compare energy efficiency and heat decarbonisation performance between different commercial buildings, which vary according to age, location, function and access to energy. The EPCs refer to building energy consumption only and not, for example, process energy or electric car-charging points. The EPC recommendations cannot simply be translated into costs and actions and enhanced energy audits are needed.

Recommendations from the EPCs can be used to build a robust business case for energy efficient investments but they are not mandatory. There can be a significant difference between EPC recommendations and guide costs and viable works and costs once on site.

SBEM and the NCM are not the only assessment tools available and are relatively simple models. There are many commercially available, dynamic simulation models that can be used in the design and assessment for new and existing buildings.

Completing energy assessments in the non-domestic sector requires a higher skills base, expertise and experience than the equivalent exercise in the domestic sector.

Technologies are always evolving, and the software is always playing catch up.

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[73] Since 9 July 2015, buildings occupied by public authorities with a floor area of 250m^2 or more frequently visited by the public must have an EPC on display. For other non-domestic buildings frequently visited by the public, the size threshold is a floor area of 500m^2 or more, and the obligation to display the EPC is contingent on the building having one. see Guidance Leaflet: Requirement to display Energy Performance Certificates (EPC) available at: https://www.gov.scot/Resource/0041/00412956.pdf

[74] http://www.legislation.gov.uk/asp/2009/12

[75] Building Standards Division (2016) *Improving Energy Performance and Emissions in existing Non-Domestic Buildings - A guide for Building Owners*, s63-001, version 1.1 July 2016, para 18, Building Standards Division, The Scottish Government, Linlithgow. available at: https://www.gov.scot/Resource/0050/00503633.pdf

The concept of EPCs, where it was explicitly commented on within the non-domestic contributions, was considered a sound basis to build upon, as was the DEC use of real data in other parts of UK – both should be utilised, but expanded to be fit for purpose going forward.

Whilst the NCM and the non-domestic EPC assessment is used as a part of the current process for assessing and improving larger non-domestic buildings, it should be noted that the further action to determine a set of improvement measures that will be applied to the building to meet energy and emissions improvement targets is delivered by a further assessment and advice function (the Section 63 Advisor) and recorded on a separate document (the Action Plan). EPC recommendations are not used for this purpose and targets are not set based upon the EPC rating. This process is set out at www.gov.scot/section63 and is subject to a review process as part of revision of standards for 2021.

5.6 Assessors

5.6.1 Assessors – The public perception

There were a significant number of responses relating to the competency and skills of assessors and in general these were not positive, with concerns raised around quality assurance, integrity and consistency.

5.6.2 Identifying the Issues

The thematic analysis categorised the 286 responses pertaining to assessor-related issues across the three public consultations according to one of three concerns and extending across 7 keywords (see Table 5.6.1). Overwhelmingly, the responses on assessor-related issues came from the PRS consultation: 253 of the 286 (i.e. 88.5%) responses.

Keyword	Broad theme: Assessor			
	competence	integrity	quality assurance	total
Surveyor skills	206	0	0	206
Quality assurance procedures	0	0	24	24
Quality assurance: consistency	0	0	20	20
Integrity	0	17	0	17
Independence	0	12	0	12
Accountability	0	0	6	6
Improvements	0	0	1	1
Total	206	29	51	286

Table 5.6.1: Frequency of Broad theme: Assessor by Keywords

Most of the contributions were classified as being concerned with assessment-related matters (see Table 5.6.2).

Keywords	Calculation	Assessment	Reporting	Total
Surveyor skills	0	200	6	206
Quality assurance: procedures	0	24	0	24
Quality assurance: consistency	0	20	0	20
Integrity	0	16	1	17
Independence	0	12	0	12
Accountability	0	5	1	6
Quality assurance: improvements	0	1	0	1
Total	0	278	8	286

Table 5.6.2: Identifying the Issues within the Assessor Responses by Issue classification

The issue of competence / surveyor skills dominates the concerns with regard to assessor-related contributions. The PRS consultation raised specific queries concerning EPC assessors, and the need for more skills and more training.

What emerges from this analysis are three areas of concern:

- surveyor skills / competence
- quality assurance consistency and procedures
- assessor integrity and independence

While we can improve the underlying methodology and procedures to improve accuracy of the models, these improvements do not address public perception of a system where there are fundamental concerns about surveyor competence, conflicts of interest, and gaming of the system. Public confidence and public buy-in to the EPC framework will depend on the public being convinced on the robustness of the procedures and the integrity of the process.

5.7 Technical issues: Room in the roof dwellings

The thematic analysis only described 1 response by the keyword 'room in the roof' which fell within the Built Form broad theme. However, within the Built Form broad theme, a further 7 responses were described as being concerned with room in the roof issues (see Table 5.7.1). These responses fell across three other keywords (see Table 5.7.2)

Broad theme: Built Form	contributions
traditional	73
older	12
rooms in roof	8
non-traditional	4
hard to treat	3
Scottish housing stock	2
size	1
whole building	1
pre-1919	1
pre-1940	1
masonry	1
Total	107

Table 5.7.1: Frequency analysis of descriptors within 'Built Form' theme

5.7.1 Identifying the Issues: Rooms in the Roof

All 8 of the room in the roof contributions were also described under both the Methodology and Modelling broad themes (see Table 5.7.2). The issues of use of defaults, the PCDB, accuracy, and U-values were identified as the concerns.

	Broad theme: Methodology (n=8)		Broad theme: Modelling (n=8)		
Keyword	Defaults	PCDB	Defaults	Accuracy	U-values
Recommendations (n=4)	1	3	3		1
Performance gap (n=2)	2			1	1
Conventions (n=1)	1		1		
Room in roof (n=1)	1			1	
Total	5	3	4	2	2

Table 5.7.2: Frequency of room in the roof contributions broken down by Methodology and Modelling broad themes and keywords

When ‘rooms in the roof’ were filtered, all of 8 the responses returned ‘defaults’ under either the Methodology and / or Modelling categories. The use of defaults in the assessment of rooms in the roof is seen as an issue.
Going beyond the use of defaults, three other specific issues emerge:

- the use of the PCDB in the costing of room in the roof improvements recommended by the EPC;
- the accuracy of the results; and,
- the resultant U-values assigned by the RdSAP defaults.

When the 8 room in the roof contributions were filtered by the Conventions broad theme, three of them identified consistency between assessors as a concern.

As part of this review, a separate Supplementary Topic Note (see Section 5.12) was prepared on issues concerning rooms in the roof, including the confusion within the conventions over when to measure rooms in the roof, the need for better direction with regard to assessor discretion, and the need for improving the definitions of rooms of the roof. This Supplementary Topic Note is published as an addendum to the main report.

5.8 Technical issues: District and Community Heating, Combined Heat & Power

5.8.1 Local Heat Networks in Scotland

Local heat networks are being proposed as an important element in shaping Scotland's energy future. This review was concerned with the LHEES responses to the consultation that opened in January 2017. Since then a second consultation was carried out between November 2017 and February 2018 on more specific policy proposals for Local Heat & Energy Efficiency Strategies and regulation of district and communal heating[76].

5.8.2 Identifying the Issues

Within the 'heating theme', the thematic analysis categorised 19 contributions as pertaining to district heating / community heating / combined heat and power (DH/CHP) across the responses to the three consultation documents, as well as by the keyword 'district heating'. The other two prominent concerns within the 'heating' theme (i.e. electric and low carbon) were mostly concern with how poorly electric heating scores in SAP / RdSAP, and concern with the undervaluing of low carbon renewables: these issues are dealt with more fully under the SAP and RdSAP metrics – see section 5.4)

Broad theme: Heating	contributions
Electric	20
District heating	19
Low carbon	15
Heat pumps	3
Thermal storage	3
Wood	3
Sizing	2
Infra-red heating	1
Micro co-generation	1
Portable	1
Total	64

Table 5.8.1: Frequency analysis of descriptors within 'Heating' theme

All of the DH/CHP contributions were also described under both the Methodology and Modelling themes (see Table 5.8.2), and these are broken down by their Issue Classification in Table 5.8.3.

[76] see https://consult.gov.scot/energy-and-climate-change-directorate/lhees-and-dhr2/supporting_documents/LHEES%20%20DH%20Regs.pdf

The two most common issues with regard to DH/CHP were:

- the accuracy of the results; and,
- the use of defaults in the calculations

Other issues such as the use of real data, Appendix T and the PCDB were of a lesser concern.

Descriptors	Methodology	Modelling
Accuracy	-	10
Defaults	4	5
Real data	1	4
Appendix T	4	-
Metric	3	0
Mapping	3	0
Alternative Models	2	-
PCDB	2	-
Total	19	19

Table 5.8.2: Frequency of district heating contributions broken down by Methodology and Modelling themes

Broad themes: Methodology and Modelling	Calculation	Assessment	Reporting	Data base	Total
Accuracy	10	0	0	0	10
Use of Defaults	5	0	4	0	9
Appendix T	0	0	4	0	4
Real Data	1	1	0	3	5
Mapping	0	0	0	3	3
Metric	2	1	0	0	3
Alternative Models	2	0	0	0	2
PCDB	2	0	0	0	2
Total	22	2	8	6	38

Table 5.8.3: Identifying the Issues within the DH/CHP contributions by Issue Classification

The potential benefits of DH/CHP will not be realised if they are not well modelled in SAP, RdSAP and SBEM. The public consultation responses on DH/CHP reflect a concern that these potential benefits may not be realised as they are not fully recognised in RdSAP.

As part of this review, a separate Supplementary Topic Note (see Section 5.12) was prepared on issues relating to DH/CHP, including comparing the impact of the different input parameters used in a full SAP assessment as opposed to an RdSAP assessment of a DH/CHP scheme. This Supplementary Topic Note is published as an addendum to the main report.

5.9 Technical issues: Ventilation

5.9.1 Modelling Ventilation

The rate of ventilation is a key component of the heat loss calculation for all buildings: the more times the air turns over within a building, the more heat needs to be replaced. It is possible to measure the air infiltration rate accurately through using air pressure testing equipment; an alternative is to estimate the air infiltration rate from a number of variables. Within RdSAP, many of the ventilation-related variables are defaults within the program.

5.9.2 Identifying the Issues

The 11 contributions identified under the broad theme of ventilation fell within one of three descriptors (i.e. infiltration, Ventrolla, and draught lobbies), and extended across two keywords (i.e. ventilation and surveyor skills) (see Table 5.9.1)

Keyword	Broad theme: Ventilation			total
	Infiltration	Ventrolla	Draught lobbies	
Ventilation	6	2	1	9
Surveyor skills	2	0	0	2
total	8	2	1	11

Table 5.9.1: Frequency analysis of Broad theme descriptors by Keywords within 'Ventilation' Broad theme

All of the ventilation contributions were also described under both the Methodology and Modelling themes (see Table 5.9.2). The use of defaults was identified as the main concern.

descriptors	Methodology	Modelling
Defaults	2	8
Metric	4	1
Appendix T	2	-
Occupant behaviour	1	1
Real data	1	1
Alternative Models	1	-
Total	11	11

Table 5.9.2: Frequency of ventilation contributions broken down by Methodology and Modelling Broad themes

The ventilation-related contributions were concerned primarily with assessment-related issues (see Table 5.9.3).

Ventilation descriptors	Calculation	Assessment	Reporting	Data base	Total
Infiltration	3	5	0	0	8
Ventrolla	0	2	0	0	2
Draught lobbies	0	1	0	0	1
Total	3	8	0	0	11

Table 5.9.3: Identifying the Issues within the 'Ventilation' contributions

As part of this review, a separate Supplementary Topic Note (see Section 5.12) was prepared on issues relating to ventilation, and in particular the default ventilation parameters used in RdSAP compared to full SAP. A sensitivity analysis of the impact of switching some of the defaults to using survey-based data was carried out as part of this modelling. This Supplementary Topic Note is published as an addendum to the main report.

5.10 Technical issues: Measuring windows

Contributions concerned with the measuring of windows or glazing generally did not feature significantly in the contributions to the three public consultations. However, given the nature of this review, this was an area that the authors thought merited more discussion in going forward with regard to whether windows dimensions should be measured or defaulted to within the RdSAP calculation process.

5.10.1 Identifying the Issues

With regard to windows and other glazing-related issues, only 5 contributions falling across four keywords were identified through the thematic analysis (see Table 5.10.1 and Table 5.10.2) Within the 'fabric' theme, the two dominant issues (i.e. stone walls and solid walls, plus thermal mass) are dealt with under the overarching topic on traditional buildings (see Section 5.2)

Broad theme: Fabric	contributions
Stone walls	23
Solid walls	20
Windows	3
Insulation	2
Wall insulation	2
Thermal mass	2
Loft insulation	1
Shutters	1
Glazing	1
Brick	1
Total	56

Table 5.10.1: Frequency analysis of descriptors within 'Fabric' theme

Keyword	Broad theme: Fabric			total
	Windows	Shutters	Glazing	
Windows	1	1	0	2
Surveyor skills	0	0	1	1
Performance gap	1	0	0	1
recommendations	1	0	0	1
total	3	1	1	5

Table 5.10.2: Frequency analysis of windows-related descriptors by Keywords

All of the windows contributions were also described under both the Methodology and Modelling themes (see Table 5.10.3). The use of defaults emerged as the main concern.

descriptors	Methodology	Modelling
Defaults	3	4
Appendix T	2	-
Accuracy	0	1
Total	5	5

Table 5.10.3: Frequency of windows-related contributions broken down by Methodology and Modelling Broad themes

The windows-related contributions were split between assessment and reporting-related concerns (see Table 5.10.4).

Window-related descriptors	Calculation	Assessment	Reporting	Data base	Total
Windows	0	2	1	0	3
Shutters	0	1	0	0	1
Glazing	0	0	1	0	1
Total	0	3	2	0	5

Table 5.10.4: Windows-related contributions by Issue Classification

As part of this project, a separate Supplementary Topic Note (see Section 5.12) was prepared on issues relating to measuring windows, including a comparison of measured window areas of almost 1400 properties from across Scotland with the default areas calculated by RdSAP algorithms – there are significant differences. Additionally, a sensitivity analysis was performed on the impact of using measured window areas, as opposed to the RdSAP model areas, on various energy performance indicators produced by RdSAP. This Supplementary Topic Note is published as an addendum to the main report.

5.11 Workshop design

Four workshops were organised around the nine topics identified in Sections 5.2 to 5.10, that is, the overarching issues and the technical issues. They were arranged as a one-day format and repeated in four locations across Scotland:

- Edinburgh, February 16th, 2018
- Aberdeen, February 22nd, 2018
- Glasgow, February 26th, 2018
- Stirling, March 16th, 2018

The first three workshops in Edinburgh, Aberdeen and Glasgow followed the same format (see Appendix B). The last workshop, which was held in Stirling, was run in partnership with Historic Environment Scotland (HES) and took a more particular focus on a common theme relating to how the RdSAP/EPC treats historic/traditional buildings.

All four workshops were open events. Invitations were sent out to everyone that could be identified from their response to one of the three publications. In some cases the responses included contact details; where no contact details were provided, their organisations (if identifiable) were contacted. It was not possible to contact everyone that responded to one of the three consultations, either because no contact details were on the response, or in some cases, the contact details had been redacted. Additionally, EAS used a database of known EPC assessors operating in Scotland, as well as circulating details to all of the Approved Organisations operating in Scotland. EAS also published the events throughout their membership.

The intention was to be pro-active in canvassing a diverse array of opinions to encourage discussion on these topics, and to allow feedback to be captured from each participant. Presentations on the broad themes distilled from the thematic analysis, and the sensitivity analysis were used to introduce ‘evidence’ of issues, to seek verification of the validity of the concerns, and to consolidate the research team’s thinking on possible actions on EPCs going forward. The presentations by the research team were followed by facilitated discussions with the participants.

Participants were asked to record any comments and/or their views of this evidence within structured workbooks to allow the research team to determine if this evidence had any bearing on consolidating or changing opinions on the effectiveness of the EPC system in Scotland. It was considered that utilising a mechanism to accurately record views from all participants individually was a more effective method of inclusive data gathering than the commonly employed focus group consensus which can obscure individuals’ comments and suppress polarised views.

A blank copy of the workbook that was used at each event is included as an addendum to this report.

The workshop presentations have been collated, converted to PDF documents, and made available to all participants at the workshops. These collated presentations are also an addendum to this report.

5.11.1 The purpose of workshop outputs

Participant feedback in the workbooks provided at the workshops represented a supplementary data source to the contributions gathered from the three public consultation documents. The intention was to allow robust validation or rebuttal of the evidence provided within each of the topic areas identified allowing the research team to confidently conclude the value of any proposal and suggest ways in which EPC provision in Scotland could be more sympathetic to the Scottish built environment: in effect, a peer review by industry stakeholders.

5.12 Supplementary Topic Notes: SAP/RdSAP sensitivity assessments

The research team carried out additional SAP and RdSAP modelling on a range of specific (domestic) to assess the impact of changing assumptions being made within RdSAP. The research team has access to a resource of the full SAP 2012 assessments for 355 archetypes that were used in the REEPS analysis that was published by the Scottish Government in 2015[77]. A selection of these properties was inputted into RdSAP assessment software following the rules and conventions employed by EPC assessors. This allowed comparative analysis of EPC results on the same property between full SAP (no inference) and RdSAP where default or 'best guess' values are employed to generate the output.

At the core of SAP and RdSAP is the same calculation engine i.e. BREDEM. Where they differ is that RdSAP defaults specific dwelling variables that are taken account of explicitly in SAP (e.g. within the ventilation algorithm the number of extract fans, flues, air vents, trickle ventilation and the presence of a draught lobby are all either defaulted or ignored in RdSAP but counted individually within SAP). Outputs from this sensitivity testing activity focused on the differences in terms of the SAP rating, the energy demand, CO_2 emissions, and the modelled fuel costs from the two assessment procedures.

Sensitivity assessments were carried out using various real data sets on:

- comparing the differences between measured window areas with RdSAP calculated areas on 1398 Scottish dwellings;
- comparing the impact of measured window areas with RdSAP calculated areas on savings calculated for wall insulation for 26 pre-1919 sandstone tenemental flats in Glasgow;
- comparing the impact of adjusting RdSAP default ventilation factors to match actual data from dwelling surveys on 183 REEPS archetypes;
- comparing the impact of using a full SAP assessment of community heating with an RdSAP assessment on 55 flats in a multi-storey high rise in Aberdeen;
- comparing the impact of altering the assumptions about the RdSAP thermal mass default on 100 REEPS archetypes;

Additionally, a modelling exercise was completed to assess the effect of changing a variable within the RdSAP stone wall U-value equations, as proposed by a representative from Historic Environment Scotland at one of the project's workshops, on a range of stone wall types and thicknesses.

The results from these sensitivity and modelling exercises are presented in more detail in the Supplementary Topic Notes document that is an addendum to this report. The results were used to inform the results and recommendations of this report.

[77] http://www.gov.scot/Publications/2015/11/4536

6. Topics: Issues, Analysis and Possible Actions

The thematic analysis, the workshop presentations, discussion and feedback, and the supplementary topic notes with additional sensitivity analysis are brought together in this section through identifying specific issues within each of nine topics, analysing the state of play, and identifying possible actions that the Scottish Government could consider to enhance the EPC process going forward.

6.1 Topic: Traditional Buildings

- Dealing with Traditional Dwellings
- Use of Defaults, Accuracy and Real Data
- Appendix T
- SAP, RdSAP, and SBEM Metrics
- Stone Wall Constructions, Heat Loss and U-values
- Solid Brick Walls, Heat Loss and U-values
- Insulating Stone and Solid Brick Walls
- Thermal Mass
- New technologies: Shutters
- New technologies: Ventrolla
- 'Non-traditional' dwellings in Scotland
- Taking Account of Insulation that Cannot Be Seen

6.1.1 Dealing with Traditional Buildings

Issue:
The public perception is that SAP, RdSAP, SBEM, and EPCs do not take account of 'traditional' buildings.

Analysis:
At one level, this perception is accurate. In the context of SAP, RdSAP and SBEM methodologies and EPCs, the term 'traditional' is not utilised in the assessment of the energy performance of a building; nor are the terms 'older', 'historic', or 'listed'. These labels do not feature in the data items collected during a SAP, RdSAP and SBEM survey, they do not appear on the EPC, nor are they entered into the software to calculate the building's energy performance, nor are they a reason for removing recommendations from the EPC: "Recommendations should be removed only if there is documentary evidence showing that a specific recommendation is not appropriate. A listed building or a property in a conservation area is not sufficient grounds in its own right to suppress a recommendation."[78]

[78] Convention 8.01, RdSAP Conventions 10 from December 31, 2017, available at https://www.bre.co.uk/filelibrary/SAP/2012/RdSAP-Conventions-10_0---from-31-December-2017.pdf

By contrast, ‘pre-1919’ is useful for exactly these reasons: it is used in assigning the default U-values to different constructions in the building. The SAP, RdSAP and SBEM calculation methodologies do differentiate properties by different age bands, e.g. pre-1919. They also differentiate wall constructions by stone, solid brick, mud, timber, cavity and system-built. Stone walls are further disaggregated into sandstone / limestone, or granite / whinstone. Depending on the age of construction of the building, these wall constructions are assigned different heat loss U-values. If ‘traditional’ is mostly synonymous with older properties, then differentiating properties by the age band of their construction, e.g. pre-1919, does take traditional dwellings into account.

The Supplementary Topic Note 1 on RdSAP and U-values further demonstrates that solid walls, stone walls, pre-1919 walls or other wall constructions are not simply one size fits all. The calculation models explicitly differentiate different types of solid walls, e.g. solid brick, different stone types, timber frame and cob. In assigning default U-values for stone walls, SAP and RdSAP distinguish between different types of stone, and then takes wall thickness into account. Further, the models also take account of the presence of an internal finish where it includes an air gap within the stone and brick wall constructions (e.g. with internal drylining or lath and plaster finish). The result is a wide range of U-values produced for dwellings falling within the age category of pre-1919 dwellings[79]. The issue is whether the range of U-values within the EPC models is sufficient, or if there is a need to expand the range. These concerns are examined below.

No further action is required with regard to the EPC-related calculation, assessment, reporting or database processes. The Scottish Government should consider publishing as part of their online guidance leaflets[80] on EPCs additional information on what SAP / RdSAP / SBEM does and does not take into account within the calculations, and how the models differentiate between different building constructions.

6.1.2 Use of Defaults, Accuracy and Real Data

Issue:
There is a perception that replacing defaults with real data or more accurate data would improve the energy assessment of traditional buildings.

Analysis:
SAP, RdSAP and SBEM are methodologies used to describe energy performance calculation models. They do not determine precisely the energy performance of every individual building; rather, as assessment tools, they work within a range of accuracy, and within a set of assumptions. However, that said, these models should

[79] and any other age category up to 1965
[80] see existing guidance notes at https://www.gov.scot/Topics/Built-Environment/Building/Building-standards/enerperfor/epcguidance

support a standard of assessment that is appropriate and sufficiently discerning to allow us to compare different properties, building types, and constructions, to support policies and programmes to actually improve the energy performance of the building stock, and to report on the impact of these improvements.

If real performance data were available on every building, then we would not have to model the building's energy performance; the actual performance data could be used. Without real performance data on a building, the use of default data of some sort is required to complete the energy performance assessment. In-situ measuring of thermal performance would be one approach to obtaining building specific U-values that could be used in the calculation methodologies. To be more precise requires a great deal of time, equipment and expense[81]. It is not feasible, practical or cost effective to monitor every individual property in detail, or to calculate or measure the actual U-value of all the fabric components within every property, hence the use of defaults that are representative of the construction of the building fabric.

The SAP, RdSAP and SBEM calculation methodologies are empirically-based models, that is, they are derived from data collection and research into the actual energy performance of existing buildings. Changes to these methodologies arise in the same way, through more data collection and research. Empirical data collection and in-situ testing resulted recently[82] in solid brick wall U-values being revised lower because the walls performed better than previously thought. The models continue to evolve as more data becomes available.

The published guidance to the SEEP Pathfinder Phase 2 funding included specific requirements to monitor the performance of the funded projects with regard to energy consumption, temperatures and relative humidity to better evaluate the impact of the refurbishment works. The guidance detailed the type of monitoring, the methodology, and the equipment that would be required.[83] Unfortunately, SAP, RdSAP and SBEM do not use 'operational data' in their assessment of the energy performance of buildings.

At least, one local authority appears to be extending this before and after monitoring approach to include "air pressurisation, in-situ U-value, and thermography on a number of specific dwelling types as part of its HEEPS ABS programme over the next two years"[84].

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[81] for example, see the description of the research methodology within BRE (2014) *In-situ measurements of wall U-values in English housing*, BRE, Garston, available at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/409428/In-situ_u-values_final_report.pdf

[82] Most recently, in RdSAP in November 2017, with the introduction of version 9.93 of the software

[83] SEEP Pilot Evaluation – information for applicants, available at http://www.gov.scot/Resource/0051/00516746.pdf

[84] Renfrewshire Council Invitation to Tender: Property Monitoring and Design Support for HEEPS ABS Programme, published 31st May 2018, available at https://www.publiccontractsscotland.gov.uk/search/show/search_view.aspx?ID=MAY320600

Data collection is important if the accuracy of the calculation methodologies is going to be improved; the more empirical research the better. There is a need to not only collect the data, but to gather it and collate it, to inform the process as well.

Possible Calculation action:
The Scottish Government to arrange for the data gathered through the monitoring of the SEEP Pathfinder projects and HEEPS ABS to be collated and assessed against improving the accuracy of the calculation methodologies.

- **Rationale: improve accuracy**
- **Time frame:** 🕐🕐🕐
- **Cost:** £ £ £
- **Impact:** ± ±
- **Magnitude:** 🏠 🏠 🏠

6.1.3 Appendix T: Improvement Measures for Energy Performance Certificates

Issue:
The recommended improvement measures on the EPC are inappropriate for traditional stone wall dwellings.

Analysis:
As long as the criteria set out in Appendix T are met, a specific improvement measure is recommended on the EPC if it increases the SAP rating of the dwelling by 0.95 SAP points or more. A considerable number of concerns were raised in the public consultation responses that this process results in measures being recommended that are inappropriate for traditional dwellings. This is dealt with in more detail in Section 6.2 on EPC Reporting and Recommendations.

6.1.4 SAP, RdSAP and SBEM Metrics

Issue:
SAP, RdSAP, and SBEM are deemed to be fundamentally flawed with regard to assessing ‘traditional’ buildings

Analysis:
Many of the concerns raised on this issue were included above as they were concerned with the accuracy of the assessments. When both the methodology and modelling categories were filtered on ‘metric’ only, the resultant four responses were concerned with the predicted fuel bills compared to actual household fuel bills, and that the impact of a number of improvements made to traditional properties, despite

their capital cost, achieved a post-improvement rating that the respondents were unhappy with.

The issue of the SAP, RdSAP and SBEM metrics are examined in more detail in Sections 6.3 and 6.4 below.

No further action:
Changing the underlying metric of SAP, RdSAP and SBEM was outside the brief of this research project.

6.1.5 Stone Wall Constructions, Heat Loss and U-values

Issue:
SAP, RdSAP and SBEM underestimate the thermal performance of stone walls.

Analysis:
The default U-values for a number of materials have been revised several times, including stone and solid brick wall constructions, since the requirement for EPCs was first introduced. For example, stone is no longer a single, age-related U-value for each stone type. Since 2012, stone walls take account of the age of the property, the type of stone, the thickness of the wall, and whether or not there was an internal lining (e.g. lath and plaster), resulting in a very wide range in stone U-values[85]. The question is whether these changes go far enough.

Several respondents to the public consultations certainly do not think they do, citing various research papers / reports where lower U-values were monitored on site. Where these papers and reports were reviewed as part of this exercise, many were found to be less than robust or systematic in their data collection. Yes, they reported on U-values being measured on-site, but were too often concerned with monitoring a single building or a very limited number of dwellings. There was further uncertainty about whether the data collection was in keeping with the international standard BS EN ISO 9869[86] which describes the apparatus to be used, the calibration procedure for the apparatus, the installation and the measurement procedures, the analysis of the data, including the correction of systematic errors and the reporting format when measuring U-values in-situ. Better reporting of the methodologies used, and more systematic reporting of the variables monitored, would enhance the reported results.

One suggestion raised during one of the workshops involved a slight amendment to the algorithms that are used in RdSAP to calculate the stone wall U-values. The impact of this suggested change is modelled in Supplementary Topic Paper 1.

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[85] for example, a pre-1919, 600mm thick sandstone lath and plaster wall will have a different U-value than a 600mm thick sandstone wall plastered on the hard, and both will have different U-values to the corresponding granite walls

[86] BS EN ISO 9869-1: 2014: Thermal insulation -- Building elements -- In-situ measurement of thermal resistance and thermal transmittance -- Part 1: Heat flow meter method

However, this modification would need to be supported with more systematic in-situ monitoring for it to be taken forward.

Within the Scottish building stock, more types of stone are used than just sandstone limestone, granite and whinstone, but the SAP, RdSAP and SBEM calculation methodologies only explicitly recognise these four (although effectively distilling the four down to 2 types). Other types of stone are dealt with by the conventions[87]. Including for more stone walls types was highlighted by a number of participants at the workshop.

Whether the current range of U-values is sufficient, or the algorithms need amendment, will need further in-situ testing and empirical data collection[88]. Certainly, given the range of stone types and constructions common across Scotland, this issue merits further investigation.

Possible Calculation action:
A systematic research programme to measure in-situ U-values for different existing stone wall types to assess the validity of the current range of U-values within RdSAP; proposed revision to the stone wall U-value calculation algorithms. This research program would probably take at least 2 years to identify and monitor sufficient properties to provide a robust empirical basis to make changes to the existing algorithms. This research programme could assess the impact of the wall condition and water saturation levels on the thermal performance of the walls.

- **Rationale: improve accuracy**
- **Time frame:** 🕒🕒🕒🕒🕒
- **Cost:** £ £ £ £ £
- **Impact:** ± ± ± ± ±
- **Magnitude:** 🏠 🏠 🏠

[87] Sedimentary type stone are to be classified in RdSAP as sandstone / limestone, while igneous and metamorphic stone are to be classified as granite / whinstone
[88] These variations are examined in more depth in Supplementary Topic Note 1 (published as Addendum to this report)

Possible Calculation action:
Extending the range of stone wall types would require collating more empirical data in terms of the type of stone and its heat loss performance so that default U-values could be derived and included into the software. This certainly could be part of the above research program. In the interim, a piece of research could collate and calculate default U-values that could be published as a stand-alone booklet (or more likely as an online data reference) that could be referred to by assessors.

- **Rationale: improve accuracy**
- **Time frame:** 🕐🕐
- **Cost:** **£**
- **Impact:** **± ± ±**
- **Magnitude:** 🏠 🏠 🏠

No further action:
Concerns were also expressed about some of the constituent components of a traditional stone wall, e.g. lime and cement mortars, lime and cement render coatings, as well as the impact of the water saturation of the wall. Currently, the default U-values for existing buildings are derived for the overall wall construction, rather than breaking it down into its constituent components. Even in a detailed U-value calculation the impact of mortar and render coatings is almost negligible as they are such a minor element in the wall. Again, the condition of the wall is not taken into account in the current energy assessment survey.

6.1.6 Solid Brick Walls, Heat Loss and U-values

Issue:
SAP, RdSAP and SBEM underestimate and over-estimate the thermal performance of many solid brick walls.

Analysis:
Using empirical data, the default U-values for solid brick walls for existing dwellings were revised downwards in November 2017 as part of RdSAP 2012 v9.93[89], to more closely reflect the U-values monitored through in-situ testing rather than a theoretical calculation. Despite this revision, and the research report it is based upon[90], the default for solid brick wall default U-values in RdSAP remains 'one size fits all'. The same default is used whether the solid brick wall is a half-brick thick, 1-brick thick,

[89] *Appendix S, RdSAP 2012, v9.93* available at https://www.bre.co.uk/filelibrary/SAP/2012/RdSAP-9.93/RdSAP_2012_9.93.pdf
[90] BRE (2014) *In-situ measurements of wall U-values in English housing*, BRE, Garston, available at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/409428/In-situ_u-values_final_report.pdf

1.5-brick thick or 2-brick thick (despite the empirical data showing an even larger discrepancy between the calculated theoretical U-values and those measured in-situ).[91]

Given that the empirical study was based on a study of 300 English houses, a 1-brick thick wall may have been the most common wall construction measured, but half-brick thick walls (i.e. between 150-180mm thick) are particularly common within the construction of the close wall in pre-1919 Scottish tenements, and 1.5 and 2-brick thick walls (i.e. between 330 – 500mm) are common (where brick was used) in the external walls of the lower floors of the pre-1919 Scottish tenements.

The SAP, RdSAP and SBEM calculation methodologies introduced the precedent of differentiating stone walls according to wall thickness in 2012. A similar approach could be applied to ranges of solid brick wall thicknesses, but rather than use an algorithm as with stone wall thicknesses, a range of thicknesses could be identified for each brick type. Assessors already measure wall thicknesses as part of a survey, so identifying the wall type as solid brick and entering its thickness could be used to access the appropriate default U-value. The result of such a change would be that the thinner solid brick walls to the close would lose more heat, while thicker solid brick external walls would lose less heat, with consequential impacts on the resultant SAP ratings.

Possible Calculation action:
Adopt thickness related U-values for half-brick thick, and for 1.5 and 2-brick thick walls, amend Appendix S accordingly, and then embed the appropriate defaults into the SAP, RdSAP and SBEM software models.

- **Rationale: improve accuracy**
- **Time frame:** 🕒🕒🕒
- **Cost:** £ £ £ £
- **Impact:** ± ± ±
- **Magnitude:** 

[91] Table 1 of the BRE 2014 report (ibid) shows the median measured U-value for standard solid brick walls (i.e. less that 330mm thick) to be 1.59 W/m^{2}K compared with the median calculated U-value of 1.92 W/m^{2}K – that is a difference 0.33 W/m2K. For non-standard solid walls (i.e. 330mm or more thick or comprised of another material other than brick) the median measured U-value was 1.28 W/m^{2}K compared with the median calculated U-value of 1.68 W/m^{2}K – that is a difference of 0.40 W/m^{2}K.

6.1.7 Insulating Stone and Solid Brick Walls

Issue:
SAP, RdSAP and SBEM can underestimate the impact of external and internal wall insulation on stone and solid brick walls

Analysis:
Regardless of the pre-1919 default stone wall construction U-value derived from the type of stone, the wall thickness, and the presence of an air gap, all of this variability is then ignored in the SAP and RdSAP calculations when either internal or external wall insulation is added to the wall. Depending on the thickness of the added wall insulation[92], SAP and RdSAP then defaults to one U-value for each insulation thickness[93]. Similarly, with solid brick walls, the beneficial effect of the presence of an air gap is ignored when either internal or external wall insulation is added to the wall.

Differential U-values could be calculated within the RdSAP program to readily account for the initial wall thickness, the air gap, and the thickness of the added insulation.

Such an approach would also address another issue discussed in more detail in Supplementary Topic Paper 1, i.e. accounting for wall insulation of less than 50mm, and instances where the thickness of the insulation falls between one of the standard default thicknesses[94]. The effect of this rounding down of the wall insulation thickness is to use a higher heat loss wall U-value in the calculation, therefore underestimating the SAP score to be achieved.

Possible Assessment action:
Publish a convention to accommodate wall insulation that is less than 50mm thick, or falls between the default thicknesses. A worked example is set out in Supplementary Topic Paper 1.

- **Rationale: improve accuracy**
- **Time frame:** 🕐
- **Cost:** £
- **Impact:** ± ± ±
- **Magnitude:** 🏠 🏠 🏠

[92] the SAP / RdSAP options are 50, 100, 150 or 200mm of internal or external insulation
[93] The SAP / RdSAP defaults are 0.55 W/m^{2}K for 50mm of internal or external wall insulation; 0.32 for 100mm; 0.23 for 150mm; and 0.18 for 200mm regardless of the type of stone, the thickness of the stone wall, and the presence of the air gap in the wall.
[94] Many walls are currently being insulated with between 70 and 90mm of insulation, but under RdSAP conventions, an assessor would take this back to 50mm.

6.1.8 Thermal Mass

Issue: RdSAP underestimates the impact of thermal mass on Scottish dwellings.

Analysis:
Thermal mass is taken as an average, medium thermal capacity for all properties assessed in RdSAP. By contrast, SAP evaluates thermal mass on a scale of low / medium / high based on the calculated thermal mass parameter. A separate Topic Paper was prepared on thermal mass for this report (see Supplementary Topic Paper 2 on Thermal Mass).

From a sensitivity analysis of 100 REEPS archetypes, changing the dwelling's thermal mass has an impact on the energy performance of a dwelling, with a difference between high and low thermal mass being up to 8 SAP points in difference. Across the sample of 100 dwellings, the mean net change in the SAP score difference was -1.4 SAP points, but the sample of houses was heavily weighted towards stone-built properties with almost no light thermal mass timber frame dwellings included in the sample. The overall impact also is heating system dependent, with a much narrower range of SAP scores seen amongst unresponsive systems than with wet central heating boilers. Adopting a variable thermal mass would impact on Scotland's energy performance indicators.

While it is possible to calculate the thermal mass parameter of each dwelling, it would also be very time consuming. Two approaches suggest themselves. The first is to use look up tables that are already available within the SAP conventions[95] - so the assessor would make a determination while on site, as part of the survey.

An alternative approach would be to revise Appendix S and the RdSAP software, so that the software made the determination of thermal mass based on the dwelling characteristics entered. Using the software to make the determination would only require one additional data collection item to be noted during the survey, and entered into the software, that is, whether the internal partition walls were effectively a masonry construction or a timber frame construction.

Possible Calculation action:
Include an assessment of the dwelling's thermal mass into Appendix S of the SAP manual, and within the RdSAP software.

- **Rationale: improve accuracy**
- **Time frame:** ⏱⏱⏱
- **Cost:** **£ £ £**
- **Impact:** **± ± ± ± ±**
- **Magnitude:** 🏠 🏠 🏠

[95] SAP 2012 Conventions v7.1, pp 37-38, available at https://www.bre.co.uk/filelibrary/SAP/2012/SAP-Conventions-v7.01.pdf

6.1.9 New Technologies: Shutters

Issue:
SAP and RdSAP do not take account of shutters.

Analysis:
The presence of shutters is a feature within some 'traditional' buildings, as well as some modern low energy design buildings. Although there is a current ISO standard for assessing the thermal performance of shutters[96], it is not included in the SAP, RdSAP or SBEM methodologies. This issue is dealt with in Section 5.9 on measuring windows.

Historic Scotland (now Historic Environment Scotland) published in 2013 a guide on *Fabric Improvements for Energy Efficiency in Traditional Buildings*[97] which included fitting shutters as one of the possible energy efficient improvements in keeping with the character of traditional buildings. If a person acted on this recommendation they would get no benefit currently in SAP or RdSAP. As the international standard exists already for modelling the impact on thermal performance, it seems a straightforward item to include within SAP and RdSAP.

Possible Calculation and Assessment action:
Include shutters within RdSAP as an item to be recorded during the survey.

- **Rationale: improve accuracy**
- **Time frame:** 🕒🕒🕒
- **Cost:** **£**
- **Impact:** **±**
- **Magnitude:**

Possible Reporting action:
Incorporate shutters into Appendix T so that they may appear as a possible improvement.

- **Rationale: improve reporting**
- **Time frame:** 🕒🕒🕒
- **Cost:** **£ £ £**
- **Impact:** **±**
- **Magnitude:**

[96] ISO 10077-1:2017**:** Thermal performance of windows, doors and shutters -- Calculation of thermal transmittance -- Part 1: General
[97] Historic Scotland (2013) Fabric Improvements for Energy Efficiency in Traditional Buildings, Historic Environment Scotland, Edinburgh

6.1.10 New Technologies: Ventrolla

Issue:
SAP and RdSAP do not take account of the Ventrolla draughtproofing system.

Analysis:
The Ventrolla draughtproofing system is not a 'new' technology as it has been on the market since the 1980s[98]. SAP and RdSAP do not specifically take account of the proprietary Ventrolla draughtproofing system. However, SAP and RdSAP do include an assessment of the draughtproofing of windows and doors within their ventilation calculations. If Ventrolla draughtproofing was installed in a building it should be taken into account by the assessor while surveying the ventilation characteristics of the dwelling.

No further action
Draughtproofing is already assessed in RdSAP and in Appendix T as an improvement.

6.1.11 Non-traditional dwellings in Scotland

Issue:
There is no differentiation between types of non-traditional housing in RdSAP.

Analysis:
Whilst the emphasis in this section has been on 'traditional' dwellings and constructions, several public consultation respondents specifically queried whether 'non-traditional' buildings should not receive similar considerations. Within RdSAP currently, for non-traditional buildings it is a matter of 'one size fits all'. All non-traditional / system-built constructions (and the two are not necessarily the same) are reduced to one catch-all, 'system-built' category within RdSAP. Non-traditional dwellings / system-built properties, regardless of the type of non-traditional construction, built during the same age band, are deemed to have the same heat loss wall U-value.

By contrast to the concerns expressed above on the appropriateness of the Appendix T recommendations for traditional walls, Appendix T makes no recommendations for insulating the walls of 'system-built' dwellings. Grant schemes where the recommendation has to appear on a dwelling's EPC for the measure to be eligible for inclusion have had to develop work-arounds for non-traditional properties or exclude them.

As with the discussion above on including more stone wall types within RdSAP, more non-traditional building types could be included with RdSAP. The basis for

[98] See https://www.ventrolla.co.uk/repair/draught-proofing

collating a wider array of wall U-values already exists – The Guide to Non-traditional Housing in Scotland 1923 -1955[99], and all of the more detailed, individual BRE reports on specific non-traditional dwelling types. As a starting point, theoretical U-values could be calculated and built into RdSAP, so that if the assessor could identify the type of non-traditional dwelling then it could be selected within RdSAP, and the appropriate U-value assigned. Failing the ability to identify the non-traditional dwelling, the current 'one size fits all' default U-value would continue.

Concrete and metal non-traditional dwellings represent at least 6%[100] of the Scottish dwelling stock, and an element of the stock that is generally expensive to insulate.

Possible Assessment action:
'System built' conjures up negative perceptions, and the term should be switched to 'non-traditional'. System-built describes a particular method of construction; not all non-traditional housing in Scotland is system-built.

- **Rationale: improve consistency**
- **Time frame:** 🕐
- **Cost:** £
- **Impact:** ±
- **Magnitude:** 

Possible Assessment action:
Clarify conventions with regard to using 'system built' as a wall type. This designation should only be used after all non-destructive means have been employed to categorise the wall type as this has a big influence on how measures are automatically generated for wall insulation.

- **Rationale: improve consistency**
- **Time frame:** 🕐
- **Cost:** £
- **Impact:** ± ± ±
- **Magnitude:** 

[99] Scottish Office Building Directorate (1987) *The Guide to Non-traditional Housing in Scotland 1923 - 1955*, HMSO, Edinburgh
[100] Personal communication with the Scottish House Condition Survey (SHCS) team within the Scottish Government where the data collected over 2014-2016 was analysed using a query provided by the authors of this report. 'Non-traditional' is not an existing category in the SHCS data analysis.

Possible Calculation action:
Use The Guide to Non-traditional Housing in Scotland 1923 -1955[1], and other individual BRE reports on specific non-traditional dwelling types, to calculate theoretical U-values for different non-traditional dwelling types and incorporate them into SAP and RdSAP.

- **Rationale: improve accuracy**
- **Time frame:** 🕐🕐🕐🕐🕐
- **Cost:** £ £ £ £ £
- **Impact:** ± ± ± ± ±
- **Magnitude:** 🏠

Possible Reporting action:
Identify appropriate wall insulation techniques for different non-traditional dwelling types so that the EPC will potentially recommend insulating the walls.

- **Rationale: improve reporting / recommendations**
- **Time frame:** 🕐🕐🕐
- **Cost:** £ £ £ £ £
- **Impact:** ± ± ± ± ±
- **Magnitude:** 🏠

6.1.12 Taking Account of Insulation that Cannot Be Seen

Issue:
Insulation installed in a dwelling is not being taken into account within the energy assessment of the dwelling because it cannot be seen.

Analysis:
The RdSAP assessment is a non-intrusive survey. As noted by one respondent,

"EPC assessors are refusing to accept that walls, floors and roof spaces have been insulated unless they can see it. So we are having properties given a low EPC rating despite the fact that we have installed insulation in the floors, walls and roof and despite the fact that we can exhibit plans showing the specification of this insulation."[101]

[101] Taken from response 304464253 available at https://consult.gov.scot/better-homes-division/energy-efficiency-programme/consultation/published_select_respondent?_b_index=120

Within RdSAP, the conventions governing adding insulation to the assessment require documentary evidence that the insulation is present. Visible evidence may not be available. With internal wall insulation and room in the roof insulation, unless the assessor is on-site while the insulation is being fitted, surveying the dwelling even a day later may result in the insulation being covered, e.g. by plasterboard. A dwelling that has had cavity fill carried out in the past may be re-rendered or externally clad so the drill pattern is no longer visible. An assessor is not able to accept solely the occupant's word that the insulation has been added; the assessor needs corroborating evidence. But then again, what guarantee is it that a property has effective cavity fill just because there is a drilling pattern? A whole industry has sprung up over the last couple of years whereby old cavity wall insulation is extracted and the cavity refilled, because the insulation has disintegrated, if it was ever there at all.

The system therefore needs to develop a mechanism for householders / owners / landlords to state what has been done to the dwelling and provide evidence so the surveyor can take this into account.

One approach would be to have contractors log completed work into an online database. Much insulation work is done currently by contractors that are PAS2030 compliant. As part of their compliance requirements they sign off 'certificates of conformity' for all PAS2030 related work, but they keep this certificate for themselves. A copy could be given to the householder, or lodged through an online portal, so that an assessor could check what work has been done.

Another option would be to allow the assessor to take account of a minimum default thickness and select an addenda item in the RdSAP software that would produce a note on the EPC that the assessment takes account of occupant declared insulation that was not specifically seen. A signed supporting letter or declaration from the householder / landlord, or household / landlord or their photographs, could be the documentary evidence to support this approach.

Possible Assessment action:
Develop procedures and conventions to take account of insulation that cannot be seen. This would include adding an addendum to the data entry take account of insulation and improvements that do not meet the current standard of documentary evidence.

- **Rationale: improve accuracy / improve consistency**
- **Time frame:** 🕐🕐🕐
- **Cost:** **£ £ £**
- **Impact:** **± ± ± ± ±**
- **Magnitude:** 🏠 🏠 🏠

Possible Assessment action:
Develop a household log book akin to the benchmark log book for boilers in which contractors would sign off insulation improvements completed in a dwelling.

- **Rationale: improve accuracy / improve consistency**
- **Time frame:** 🕛🕛🕛
- **Cost:** £ £ £
- **Impact:** ± ± ± ± ±
- **Magnitude:** 🏠 🏠 🏠

Possible Data Base action:
Develop a database alongside the EPC register to upload PAS2030 certificates (or the equivalent) that can be accessed by householders and assessors to check if insulation has been installed.

- **Rationale: improve accuracy**
- **Time frame:** 🕛🕛🕛🕛🕛
- **Cost:** £ £ £ £ £
- **Impact:** ± ± ± ± ±
- **Magnitude:** 🏠 🏠

6.2 Topic: EPC reporting and recommendations

- Recommendations: Appendix T Method
- Reference values and costs within the Product Characteristics Database
- Meeting minimum standards
- Recognising new technologies
- Occupant behaviour and recommendations
- Format of the 'Recommended measures' table
- Inappropriate recommendations
- Building condition

6.2.1 Appendix T Methodology

Issue:
The recommendations presented on the EPC are too formulaic, lack flexibility, often inappropriate for the building, and do not take account of owner or occupier's circumstances.

Analysis:
The recommendations that appear on a domestic property EPC are generated automatically by the SAP and RdSAP software. The measures that appear, the order in which they appear, and even the rationale why some recommendations appear and others do not, are governed by the Appendix T methodology which has a specific sequence for the consideration of measures, and a set of logical decision-making criteria to test the applicability of the measure, before making a recommendation.

The assessor does not select the measures to be included on the EPC report, yet they are allowed to delete recommendations if they have a good reason[102]. Thus, some recommendations appear on the EPC simply because a set of circumstances determined by SAP Appendix T are met, for example:

- wind turbines are recommended for all houses or bungalows located in a **rural location**, which do not have an existing wind turbine;

[102] RdSAP Convention 8.01 notes:
"Recommendations should be removed only if there is documentary evidence showing that a specific recommendation is not appropriate. A listed building or a property in a conservation area is not sufficient grounds in its own right to suppress a recommendation.

If a recommendation is removed this must be recorded in site notes.

Further guidance on specific recommendations can be sought from an appropriate professional organisation, for example heating engineers, building control officers, product manufacturers, trade associations, etc." See RdSAP Conventions V10, available at https://www.bre.co.uk/filelibrary/SAP/2012/RdSAP-Conventions-10_0---from-31-December-2017.pdf

- solar hot water systems and solar PV systems are recommended regardless of the orientation, the overshading, or the appropriateness of the roof structure;

On the other hand, potential improvements are omitted simply because of Appendix T rules, for example:

- improvements being excluded from the list of recommendations because they do increase the SAP score by at least 1 SAP point (see Appendix A.6)
- internal or external wall insulation not being recommended for 'system built' properties
- failing to recommend connection to a local heat network, when one is available is discussed in more detail in Section 6.7.

The specification for all of the potential improvements is fixed within Appendix T and it is not possible for the assessor to amend the specification to model materials or equipment. Improvements cannot be adjusted to reflect better-performing products of a type (e.g. an insulation with a lower thermal conductivity value), or to take account of an owner or occupier's circumstances (e.g. secondary glazing may be a more affordable and appropriate option for a householder than replacement double glazing). Low impact measures may not individually meet the SAP 1-point threshold to be recommended on the EPC, but when bundled together as a package, they may more than meet this minimum threshold to be included – but this option is not available currently.

The use of the term 'Recommendations' on the EPC may have some unintended consequences. The recommendations listed on an EPC are neither recommendations for the particular property nor a specification of works. However, the current process gives the impression that the recommendations are the result of a well-considered, authoritative process. Appendix T provides general suggestions, not ones specific to the property or its context, but nowhere is this stated on the EPC. This may lead to both inappropriate recommendations and poorly informed investment decisions. The wording could be amended to clarify the purpose and also to direct the householder to seek expert advice. 'Potential improvement options' may be more suitable than 'Recommendations'. The format of the non-domestic EPC provides a model.

As an asset rating, the standardised recommendations on the EPC may have been sufficient; but as the EPC's purpose expands to include elements of regulation and compliance, then so too should the advice report evolve.

Flexibility is needed in how the potential improvements are presented, and also in the type of measures included. With the setting of housing energy efficiency standards, the EPC could help to inform the owners or the occupants of the sorts of measures to invest in to meet a range of banded targets, for example, presenting packages of improvement measures based on achieving a set EPC banding threshold such as getting to SAP Band 'E' or 'D' or 'C'.

Currently the two approaches would appear to present themselves: reformulating the whole of the advice report including the recommendations, along with the requisite changes to both Appendix T and all of the calculation software programs to accommodate these changes, or developing an 'addendum' or parallel process built upon the EPC.

There is recent experience with this latter approach, that is, the Occupancy Assessment (OA) process devised for the Green Deal Advice Report (GDAR). The OA was a separate, detailed assessment of the household including consideration of a wider array of improvements than available with RdSAP. However, it was built upon and informed by the EPC assessment, which had to be completed first. The assessor provided householder-specific, building-specific advice, coupled with assessments advice and improvements tailored to the needs of the building and the circumstances of the householder.

Expansion of the function of the EPC in this way would require the development of existing assessor skill sets, however many of these are already well developed. It would require that the assessor take on more responsibility in relation to the decisions being made on the range and type of improvement measures, including building packages of measures to achieve certain EPC bands. This will also offer the opportunity to recommend low cost measures which may not affect the SAP score, but may provide a benefit in comfort to the occupant. It would also include an element of energy advice.

Possible Reporting action:
In order to avoid significant material changes to the EPC as required for EPBD, consideration should be given to a separate associated energy efficiency advice report or improvements report. This report would be both methodologically and administratively linked to the EPC itself.

- **Rationale: improve reporting / recommendations**
- **Time frame:** 🕛🕛🕛🕛🕛
- **Cost:** £ £ £ £
- **Impact:** ± ± ± ± ±
- **Magnitude:** 🏠 🏠 🏠 🏠 🏠

Possible Reporting action:
The format of the EPC in Scotland should reflect on the potential for assistance through Scottish Government schemes and/or the Energy Companies Obligation. Assessors are currently required to identify the tenure of the properties being assessed and many of the schemes for assistance are targeted at specific tenures. Messages around whether the property does or does not meet a sectoral EPC band target could be provided on the EPC.

- **Rationale: improve reporting / recommendations**
- **Time frame:** 
- **Cost:** £ £ £ £ £
- **Impact:** ± ± ± ± ±
- **Magnitude:** 

Possible Assessment action:
Support the development of a wider role for EPC assessors in Scotland through further training, and CPD.

- **Rationale: improve consistency**
- **Time frame:** 
- **Cost:** £ £ £ £
- **Impact:** ± ± ± ± ±
- **Magnitude:** 

Possible Assessment action:
Clarify RdSAP conventions with regard to circumstances under which an assessor can / cannot choose to suppress automatic recommendations taking account of a householder's circumstances.

- **Rationale: improve consistency**
- **Time frame:** 
- **Cost:** £
- **Impact:** ±
- **Magnitude:** 

6.2.2 Reference Values and costs within the Product Characteristics Database

Issue:
The current PCDB does not meet Scottish needs: it is too generic and too inaccurate to assist owners and occupiers in making informed investment decisions on how to improve the energy efficiency of their property.

Analysis:
The capital costs quoted on the EPC for installing potential improvement are fixed within the PCDB, and are often presented as a cost range rather than a specific cost, and in some instances, a very wide cost range. They are intended only to be illustrative in the broadest sense. Accordingly, these costs do not vary across the country. The costs do not vary on the basis of known building characteristics such as the size of building, or whether it is a flat or house. For example, cavity wall insulation is presented as the same price regardless of the area of wall that can be treated, even where this information is known within the model as it calculates the external wall area. The costs do not account for preparation costs, meeting health and safety requirements or additional occupant costs e.g. decanting and redecoration. The costs do not account for planning or building warrant permissions where these are required. Estimated costs presented in this way are not helpful to either the building owner or the occupier, and may misrepresent both the size of the investment required and the potential savings and paybacks.

Whilst the PCDB data is reviewed regularly, and the date of review is visible for each improvement cost, it appears that the costs are not reviewed very frequently[103]. It is not possible for the assessor to input local costs into the calculation. This inflexibility was a protection for the loan calculation known as the 'Golden Rule' under the Green Deal, and a protection against unscrupulous salespeople misrepresenting the benefits of their wares. This same inflexibility could act as a point of contention for assessors providing EPC services to landlords and home owners in the future where investment decisions are being made on the basis of information on the EPC to meet specific EPC standards or targets.

For reporting capital costs of measures, this needs to be an area where the assessor can provide a localised price if this is known, and that it should consider the variance of price by the proportion of the property being treated.

In addition to this, the annual savings stated, whilst better than a general range, may be better valued if they were in some way reflective of the occupant's behaviour and circumstances.

While RdSAP takes account of local Scottish climatic variables when assessing the impact of improvements, it does not take account of Scottish fuel prices. The PCDB uses national fuel prices that are updated every six months. However, the average

[103] See https://www.gov.scot/Publications/2015/11/4536

costs for electricity and gas supply in Scotland are already collated by Ofgem and reviewed every 6 months[104]. Why not embed these prices into the PCDB, so that the reported savings are not only based on the local climate but local fuel prices as well?

Possible Assessment action:
Enable and allow assessors to modify the PCDB costs for improvement works, allowing the reporting of capital costs of improvement measures to be made more specific to the community where the works would be carried out.

- **Rationale: improve consistency**
- **Time frame:** 🕒🕒🕒🕒
- **Cost:** £ £ £ £
- **Impact:** ± ± ±
- **Magnitude:** 🏠 🏠 🏠 🏠 🏠

Possible Assessment action:
Allow variations in the costs of the works proportionate with the percentage of the property being treated.

- **Rationale: improve consistency**
- **Time frame:** 🕒🕒🕒🕒
- **Cost:** £ £ £ £
- **Impact:** ±
- **Magnitude:** 🏠 🏠

Possible Calculation action:
Establish a Scottish PCDB reference database to allow for Scottish-based inputs such as fuel costs and improvement costs, to calculate the EPC outputs on the EPC such as the savings on fuel costs, and the paybacks.

- **Rationale: improve accuracy**
- **Time frame:** 🕒🕒🕒🕒🕒
- **Cost:** £ £ £ £ £
- **Impact:** ± ± ± ± ±
- **Magnitude:** 🏠 🏠 🏠 🏠 🏠

[104] https://www.ofgem.gov.uk/about-us/how-we-work/working-consumers/protecting-and-empowering-consumers-vulnerable-situations/consumer-vulnerability-strategy/vulnerable-customer-safeguard-tariff

6.2.3 Meeting Minimum Standards

Issue:
The current EPC reporting format does not allow for target setting, nor does it explicitly link to policy targets (e.g. EESSH) which utilise the EPC rating.

Analysis:
The role and purpose of the EPC is evolving: what was an asset rating for the purposes of sale or rental of properties is becoming a tool in regulation and compliance.

EESSH currently sets energy efficiency standards for social landlords to comply with by 2020, and the Scottish Government is currently consulting on their successor. The PRS consultation proposed minimum energy efficiency standards with the intention that these would become more onerous over time. As an RdSAP data entry item is the tenure, and distinguishes between private and social landlords, this information could be used to inform the recommendations presented on the EPC.

As the announced intention of the Scottish Government is to increase the minimum standards over time, just meeting the minimum energy standard now may not be sufficient in a few years' time.

Building owners should be encouraged to go further to prevent repeated phases of improvement in the future. However, there is a downside for landlords, as good as they may want to be: it is difficult to maintain standards when factors that influence RdSAP are not controlled by the building owner (e.g. occupant actions can impact on the assessment for an EPC, e.g. low energy lighting can be removed, loft insulation can be disturbed, electricity meter types changed when switching supplier which may all impact negatively on the EPC rating).

The duality of purpose could be achieved through the recommendations and advice report running in parallel with the asset rating. A duality of purpose already is embedded within the EPC as the SAP rating and fuel costs use two very different cost and climate bases, so this could be extended to the EPC report as well.

Possible Reporting action:
In order to avoid significant material changes to the EPC as required for EPBD, consideration should be given to a separate associated energy efficiency advice report or improvements report. This report would be both methodologically and administratively linked to the EPC itself.

- **Rationale: improve reporting / recommendations**
- **Time frame:** 🌍🌍🌍🌍🌍
- **Cost:** £ £ £ £ £
- **Impact:** ± ± ± ± ±
- **Magnitude:** 🏠 🏠 🏠 🏠 🏠

6.2.4 Recognising New Technologies

Issue:
New technologies are not well accommodated for within the EPC process.

Analysis:
Driving innovation and finding new solutions to tackling difficult problems requires a significant amount of support, both financial and also by way of recognition of the impact of such measures.

SAP is primarily an evidence-based model. Introducing new products within an existing class of measure can be a simple matter of obtaining the certification of performance under an agreed methodology of testing e.g. a new more efficient boiler will follow the EU guidance on testing to obtain efficiency data which can be included in the PCDB: the standards are agreed, the testing method and procedures agreed, and the procedures for updating the PCDB established. When a new product or technique appears that is outwith the agreed protocols, then the only possible route is by empirical and peer-reviewed research to validate the claims, and to determine a new method or algorithm to integrate into the existing SAP methodology. In some cases the technological change may even demand a revision of the underpinning BREDEM.

As technological innovations can occur faster than changes in calculation methodologies, a process known as Appendix Q[105] was introduced at the time with SAP 2005 as an interim route into SAP: the Appendix Q process could be used to include a new technology before an update to the underlying SAP model. The software allowed for the impact of improvements calculated through the Appendix Q process and entered into the calculation. The assessment of heat pumps and mechanical ventilation heat recovery systems were developed through the Appendix Q process.

The intention was that Appendix Q would be an evolving process, so that a new technology assessed in Appendix Q in one iteration of SAP (e.g. SAP 2009) would become embedded in the next (e.g. SAP 2012); it would subsequently be incorporated into RdSAP. Unlike the full SAP program, there is no facility for Appendix Q calculated savings to be input into the RdSAP software. As the primary route for EPCs in existing homes is the RdSAP methodology, this means that, in practice, Appendix Q cannot be used for this purpose.

The problem with trying to short cut the process of gathering empirical data on new technologies and the process of validation is that many new technologies are also accompanied by claims that cannot be substantiated by rigorous testing.

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[105] https://www.ncm-pcdb.org.uk/sap/page.jsp?id=18

The current model for lighting energy does not differentiate the savings impact of light emitting diode (LED) lighting over that attributed to compact fluorescent lighting (CFL). Whilst both are 'low energy' compared to traditional incandescent lighting, LED technology does confer additional savings on top of those provided by CFLs.

A completely different aspect of new technology is the development of new in-situ non-destructive testing processes which are not utilised fully in the assessment process. Infra-red technology can provide valuable data to tackle thermal bridging, and air pressure testing can actually be directly utilised in SAP but only full SAP, not within RdSAP. Air pressure testing is discussed in more detail in Section 6.8

Possible Assessment action:
Amend the RdSAP software to allow for the inclusion of Appendix Q calculated savings for technologies not currently incorporated in RdSAP, following the same guidelines that are currently applied to using such procedures in SAP.

- **Rationale: improve consistency**
- **Time frame:** 🕐🕐🕐🕐
- **Cost:** £ £ £ £ £
- **Impact:** ± ± ±
- **Magnitude:** 🏠

Possible Calculation action:
Amend RdSAP procedures and software to differentiate between CFLs and LED with regard to assessing lighting energy consumption, and potential savings.

- **Rationale: improve accuracy**
- **Time frame:** 🕐🕐🕐
- **Cost:** £££
- **Impact:** ±
- **Magnitude:** 🏠 🏠 🏠 🏠

Possible Calculation action:
Allow the inclusion of in-situ test results such as air pressure testing or U-value measurements to be included in the RdSAP assessment of existing properties. Such procedures are already defined in SAP for dwellings.

- **Rationale: improve accuracy**
- **Time frame:** 🕐🕐🕐
- **Cost:** £ £ £
- **Impact:** ± ± ± ± ±
- **Magnitude:** 🏠 🏠 🏠 🏠 🏠

6.2.5 Occupant Behaviour and Recommendations

Issue:
Occupant behaviour is not accounted for within the standard SAP, RdSAP and SBEM methodologies, and their recommendations.

Analysis:
As an asset rating of a building, the assessment process is not concerned with how the occupants use the building, which can impact on actual fuel costs, energy consumption, emissions, and potential savings quite significantly. With the move towards using the asset rating for compliance and regulation purposes, the EPC outputs could be better utilised within a minimum standards assessment and to better inform the building owner or occupier.

Again, the recent experience of the Occupancy Assessment within for the Green Deal Advice Report provides a precedent on how this may evolve. The OA was separate, detailed assessment of the household along with a consideration of a wider array of improvements than available with RdSAP. However, it was built upon, and informed, by the EPC assessment, which had to be completed first.

In order to avoid significant material changes to the EPC as required for EPBD, consideration should be given to a separate associated energy efficiency advice report or improvements report. This report would be both methodologically and administratively linked to the EPC itself.

Possible Reporting action:
Use the EPC data to provide tailored advice and support to householders by developing a parallel reporting process.

- **Rationale: improve reporting / recommendations**
- **Time frame:** 🕐🕐🕐🕐🕐
- **Cost:** £ £ £ £ £
- **Impact:** ± ± ± ± ±
- **Magnitude:** 🏠 🏠 🏠 🏠 🏠

6.2.6 Format of the 'Recommended measures' table

Issue:
The format of the 'Recommendations' table is not easily understood (e.g. the mix of cumulative impacts to the SAP rating reading down the table in one column and the impact of individual measure effects provided as a cost saving (£/year) in another column of the same table).

Analysis:
Many respondents felt that the savings calculated for the application of potential improvements do not reflect reality: the costs were not real, while the fuel costs do not take account of the actual occupants or their use of the home.

The list of recommendations on an EPC is neither a job sheet for planned works, nor is it a design specification. Some workshop respondents highlighted that some occupants perceive the EPC to be a quotation for work or 'price promise' or a guarantee of reduced fuel costs. The description of improvements should be sufficiently generic, and come with an explicit note requiring the need for more professional consideration and specification. It is particularly important to communicate the factors which may introduce a deviation from the expected performance i.e. the 'performance gap'.

The 'performance gap' is widely recognised as an issue for the industry and is being tackled in some way through the PAS 2030 and PAS 2035 (Quality Mark) certifications.

The format of the recommendations section of the EPC needs to be reviewed to fit its purpose, providing easily understood data for a public who are not built environment professionals.

Possible Reporting action:
A consumer review of the EPC format is needed in order to revise the way that information is presented on the document so that it is understandable by the householder, and not just a technical audience. The review should consider information such the values and terms used and what these mean to the consumer. The certificate itself is an authorised legal document; however, the information contained within certain sections is indicative and not an approved schedule of planned works.

- **Rationale: improve reporting / recommendations**
- **Time frame:** 🕒🕒🕒🕒🕒
- **Cost:** £ £ £ £ £
- **Impact:** ± ± ± ± ±
- **Magnitude:** 🏠 🏠 🏠 🏠 🏠

6.2.7 Inappropriate Recommendations

Issue:
The recommendations on the report are inappropriate for traditional buildings.

Analysis:
It is widely recognised that older vapour permeable structures need to remain well ventilated in order for interstitial moisture to naturally evaporate. The application of modern insulation materials which encapsulate the building, creating a vapour impermeable barrier can, over time, affect the integrity of the structure within and also contribute to an increase of moisture levels within the home i.e. affecting both the occupants and the building.

In all buildings, whether vapour permeable (e.g. sandstone) or vapour impermeable (e.g. concrete), the impact of insulation improvements on the ventilation of the dwelling must be taken into consideration. PAS 2030 accredited installers should be working to a method which minimises the ventilation impact of improvement measures. Where an improvement requires a building warrant, this needs to take regard of the impact of the measure in relation to Section 3 of the Scottish Building Standards. In practice however, it is recognised that where this has not been addressed, that the internal environments can become damp without significant occupant intervention.

For historic buildings and those with protected listing status, certain types of fabric improvement to buildings can obscure or even destroy internal and external features which are an important part of our built heritage. Where the need for such protection/conservation is clear it should be reasonable for assessors to exclude certain recommendations on the grounds of aesthetic or cultural heritage damage. That said, as already noted above, the list of recommendations on an EPC is neither a job sheet for planned works, nor is it a design specification. Providing detailed design specifications is outwith the scope and purpose of an EPC; however as the data is captured at the point of assessment, this could be utilised to present cautionary messages to the occupant about the risk of these consequences.

A supplementary professional survey separate to the EPC was suggested in several responses, even going as far as to say that the recommendations section should just be removed from the EPC as it can be misleading and unhelpful.

It was already discussed in Section 6.2.4 above that the assessor is not in control of the recommendations on the EPC as these are a direct consequence of the software and Appendix T. It was also recommended as a possible action that the guidance on when an assessor can and cannot suppress a recommendation be revised. That recommendation is reinforced here.

Possible Reporting action:
Amend the wording on the EPC with regard to recommendations for specific construction types, that more additional expertise is needed. This could be done achieved through the assessor selecting an addendum item for the need for professional expertise with specific construction types.

- **Rationale: improve reporting / recommendations**
- **Time frame:** 🕒🕒🕒🕒🕒
- **Cost:** £ £ £ £ £
- **Impact:** ± ± ± ± ±
- **Magnitude:** 🏠 🏠 🏠 🏠 🏠

6.2.8 Building Condition

Issue:
The EPC assessment does not take account of building condition.

Analysis:
An EPC energy assessment is not a building condition assessment. Disrepair is an issue in the private sector, even just basic maintenance cleaning gutters etc. In addition, the awareness of the limitations imposed by listed buildings and conservation areas is poor, as is the scope of the Tenements Act and its role in enabling disrepair works.

It is recognised through surveys such as the Scottish House Condition Survey that serious disrepair leading to moisture ingress etc. is a problem for some parts of the national building stock. There are often competing priorities for housing providers and, clearly, making buildings wind- and water-tight is a basic tolerable standard that should be addressed before any energy efficiency works.

Currently, the condition of the building is outwith the scope of EPC assessment unless it has implications for cavity wall insulation with regard to existing homes.

Before energy efficiency related improvements are carried out on a building, a condition report may be required to ascertain if any area of a building's disrepair could have an adverse impact on the installation of an improvement, on its performance. A system to assess the health and safety of dwellings in Scotland, the Repairing Standard, operates in the private rented sector[106]. Again, with appropriate training an energy assessor could make an assessment on some elements of disrepair, and select an appropriate addendum within the data entry, which would add a note to the EPC.

[106] https://www.mygov.scot/landlord-repairs/repairing-standard/

Possible Reporting action:
Amend the wording on the EPC with regard to recommendations where the building is obviously not wind and weather tight that additional work may be required for the benefits of any improvement works are to be realised. This could be done achieved through the assessor selecting an addendum item for the need for professional expertise with specific construction types.

- **Rationale: improve reporting / recommendations**
- **Time frame:** 🕒🕒🕒🕒🕒
- **Cost:** £ £ £ £ £
- **Impact:** ± ± ± ± ±
- **Magnitude:** 🏠 🏠 🏠 🏠 🏠

6.3 Topic: SAP and RdSAP Metrics

- Energy efficiency metrics and asset ratings
- Using real data
- Using Scottish data
- Occupancy factors

6.3.1 Energy efficiency metrics and asset ratings

Issue:
The presentation of properties on a rating scale (A – G) banded metric is a widely understood way of expressing progression from poor (G) to good (A). However, the basis of, the purpose of, and the value of the other data on an EPC is less well understood.

Analysis:
As a metric, SAP is not consistent over time. Changes to the methodology mean that every time the version of SAP changes a new scale evolves. This can be seen in the results of the Scottish House Condition Survey, with a drop in the mean SAP score after the introduction of a new version. For example, changes to the heat loss characteristics of party walls introduced in December 2014 as part of SAP 2012, resulted in SAP scores for mid-terrace houses falling by about 4 SAP points. Using a single SAP score as the basis of compliance means that a dwelling that just complies in one iteration of SAP may not when recalculated when the next one comes along. It may be more appropriate to use the SAP A-G bandings and recalibrate the banding scales going forward. That however, is beyond the remit of this report.

The SAP rating is an energy cost index. Fuel prices used in the SAP calculation are those hard coded into Table 12 in the SAP methodology[107], and for SAP 2012 and RdSAP, were derived from the 3-year national average fuel prices between 2011 and 2013 (so are well out of date). These embedded values only change with a revision of the underlying SAP model, so are not expected to be updated until the release of SAP 10.

To mitigate the impact of changing fuel prices over time, a correction is factored into the determination of the SAP rating[108] to correct for the "general rate of fuel price inflation". As this correction is a single figure weighted by a population proportion of the main fuels used, it does have a tendency to mirror the cost of mains gas over time over any other fuel. In general terms, as mains gas price varies up or down other fuels normally follow this, so the correction factor is intended to keep the rating

[107] Table 12: Fuel prices, emission factors and primary energy factors [https://www.bre.co.uk/filelibrary/SAP/2012/SAP-2012_9-92.pdf]
[108] "An energy cost deflator term is applied before the rating is calculated. It will vary with the weighted average price of heating fuels in future so that the SAP rating is not affected by the general rate of fuel price inflation. However, individual SAP ratings are affected by relative changes in the price of particular heating fuels.", see https://www.bre.co.uk/filelibrary/SAP/2012/SAP-2012_9-92.pdf, p226 (footnote r)

stable over time[109]. Where the cost of any particular fuel changes significantly differently to mains gas, then SAP ratings in these properties may vary over time. Better stability in the ratings over time would be achieved if the price correction for each fuel was measured against price changes for the respective fuel, and not be determined effectively by changes in mains gas prices.

Possible Calculation action:
The impact of the changing fuel prices on the SAP rating over time is accounted for in quite a blunt way within SAP and RdSAP. Rather than use an overall average fuel price index, a fuel price index for each fuel should be calculated and embedded with the SAP and RdSAP calculations. Going forward we can no longer have the confidence that all fuel costs will follow a similar trend or direction.

- **Rationale: improve accuracy**
- **Time frame:**
- **Cost:** £ £ £ £ £
- **Impact:** ± ± ± ± ±
- **Magnitude:**

This impact of fuel prices on the SAP ratings resulted in the differential EESSH standards for social landlords for the different dwelling types depending on the primary heating fuel. Lower target scores were set for electrically heated dwelling types. Further, the target scores were revised for all electrically heated dwelling types within the EESSH reference tables where the SAP score is calculated using SAP 2012 software, rather than SAP 2009[110] software. The impact of the energy cost deflator kept the ratings comparable between SAP 2009 and SAP 2012 for properties heated by mains gas. However, as the price of electricity had changed by a greater magnitude than mains gas over the same period, an additional adjustment in the policy target was required to ensure consistency over time.

Setting single targets that are effectively determined by the price of mains gas penalises owners and occupiers being that are reliant on other fuels, especially for space heating and hot water. This may be for no other reason than a property is located well off the gas grid. The proposals in the PRS consultation set single banding standards, and in the proposed timetable of making the banding more onerous, for private rented properties regardless of the primary heating fuel. Meeting these targets will be more difficult in off-gas grid areas.

[109] Without this correction, the effect of rising fuel prices would result in SAP scores falling over time.
[110] Tables 1 and 2: [http://www.gov.scot/Resource/0052/00529504.pdf]

Possible Reporting action:
Develop differential SAP targets for dwellings for different primary heating fuels.

- **Rationale: improve reporting / recommendations**
- **Time frame:** 🕐🕐🕐🕐🕐
- **Cost:** £ £ £ £ £
- **Impact:** ± ± ± ± ±
- **Magnitude:** 🏠 🏠 🏠

The rating is also affected by the type of electricity meter[111] serving the property as identified by the assessor, but the actual electricity tariff applied is determined by the software not the assessor, and is dependent on both the type of electric heating and the meter[112]. Common Scottish electricity tariffs, such as 'Total Heating / Total Control'[113], and 'Comfort Plus Control'[114] are not offered by all electricity suppliers, and so a household may find their tariff has been changed to one that is very different in its price make up when they switched supplier regardless of the installed meter, or their meter may be changed, with unintended consequences on the SAP rating.

Landlords can install appropriate meters for the type of heating, and low energy light bulbs to ensure compliance with a SAP standard. Tenants can remove heating, switch tariffs, and replace low energy light bulbs with less efficient lighting; all to the detriment of the SAP rating.

Possible Reporting action:
Where the rating is subject to the type of metering (e.g. with electric storage heating) or the presence of low energy lighting, a note should be added to the EPC stating that switching tariffs or replacing the low energy lighting with less efficient lighting may have a negative impact on the rating to landlords and owners on the actions that can have an adverse impact on the SAP rating.

- **Rationale: improve reporting / recommendations**
- **Time frame:** 🕐🕐
- **Cost:** £
- **Impact:** ± ±
- **Magnitude:** 🏠 🏠

[111] The SAP and RdSAP options are 'single', 'dual', '18-hour', '24-hour' or unknown electricity meter.
[112] See Table 12a of the SAP manual.
[113] Scottish Hydro's 24-hour tariff
[114] ScottishPower's 24-hour tariff

In terms of developing a new narrative for the energy information on an EPC and the general public, the assessment needs to make sense within the context of the use of fuel within the home. The EPC presents data in a way that appears obscure: running costs and potential savings are presented for a 3-year period. There is no built-in allowance for the possible changing of prices within this 3-year period, which seems unreal. For majority of people on salaries, this should be annual. For those on benefits, then perhaps monthly or even weekly may provide a better way to understand the purpose of this metric.

Possible Reporting action:
Adjust the presentation of fuel costs and savings to reflect annual fuel bills (not 3-year totals) and annual savings. There may also be some benefit of also including what the annual total converts to in terms of an average weekly fuel bill in summer and winter, to better inform householders.

- **Rationale: improve reporting / recommendations**
- **Time frame:** 🕐🕐🕐
- **Cost:** £
- **Impact:** ±
- **Magnitude:** 🏠🏠🏠🏠🏠

Possible Reporting action:
Consider the value that can be added to the EPC process with a separate occupant report. This kind of approach could help to address the view that the EPC in itself should not fundamentally change; the data used to generate it could add significant value to a supplementary advice report which then brings into play specific occupant factors.

- **Rationale: improve reporting / recommendations**
- **Time frame:** 🕐🕐🕐🕐🕐
- **Cost:** £ £ £ £ £
- **Impact:** ± ± ± ± ±
- **Magnitude:** 🏠🏠🏠🏠🏠

However, not everyone agrees that the existing EPC format should be further developed to accommodate an occupancy component within the rating or the EPC be customised to the occupant. A compromise position could be the adoption of a parallel process which maintains the current standardised format for the EPC to fulfil the EPBD, and a separate occupancy rating. This approach may also allow the assessment of the impact of energy amenity not related to the energy required for heating space, hot water, ventilation and the provision of adequate lighting.

The Scottish EPC for domestic buildings publishes an Environmental Impact Rating alongside the 'Energy Efficiency Rating' (i.e. the SAP score) which to all intents and purposes appears to be ignored in the policy context. Retaining both on the front page of the Scottish EPC may appear confusing to some, however it does support the operation of both social and environmental policy aims.

The development of greater Scottish renewable generation capacity is not reflected well in either the energy efficiency or the environmental impact metric. The EPC currently adopts a GB context for energy and associated emissions. With Scottish targets for emissions reductions, it follows that the EPC in Scotland should measure environmental impact against these targets using Scottish data. Some have argued that this should go further and that, just as we could adopt an occupant focus for a parallel report which aims to give a property specific operational rating on a domestic property, we could also extend that view to the emission rating, at the very least within a Scottish context or even a local distribution geography e.g. an emissions ratings for Orkney or Shetland respectively.

Possible Calculation action:
Review the financial benefit of embedded generation within the EPC process. Currently the SAP score on the EPC is improved with electricity generating renewables; however, it is not clear how this translates to an energy cost saving for the occupant.

- **Rationale: improve accuracy**
- **Time frame:** 🕛🕛🕛🕛🕛
- **Cost:** £ £ £ £ £
- **Impact:** ± ± ± ± ±
- **Magnitude:** 🏠 🏠

Despite the claim on the EPC, since the introduction of SAP 2012, the carbon dioxide emissions are not just but about CO2, but also include equivalencies for other greenhouse gases in the calculation. This should be clarified in the EPC wording.

Possible Reporting action:
Adjust the wording on the domestic EPC so that it refers to carbon dioxide equivalent (or CO_2e) emissions rather than simply carbon dioxide.

- **Rationale: improve reporting / recommendations**
- **Time frame:** 🕛
- **Cost:** £
- **Impact:** ±
- **Magnitude:** 🏠 🏠 🏠 🏠 🏠

6.3.2 Using real data

Issue:
Assessments of buildings should use real consumption data, and not standardised or modelled data.

Analysis:
SAP was developed using standardised reference values to ensure consistency in assessments, and to allow ratings to be comparable across the country.

As stated previously, confusion could result if using real fuel cost data had a direct impact directly on the EPC rating, as this would not allow the results to be comparable. Thus, the context for use of real data is likely to be a parallel report. In all cases though, the EPC should state the costs that have been used in the calculation, both modelled and real, with full disclosure of reference data.

In-situ measurement of a building's thermal performance would be prohibitively expensive.

Conventional methods of collecting 'real data' are time-consuming, and expensive, and for an asset rating, unlikely to be valued or supported.

No further action

6.3.3 Using Scottish data

Issue:
Assessments of building should use Scottish specific data, and not standardised or modelled data.

Analysis:
SAP was developed using standardised reference values to ensure consistency in assessments, and to allow ratings to be comparable across the country. Over time, within the information presented on the EPC has evolved, so now only the SAP score, and the recommendations and their respective cost range remain nationally comparable. The use of local climate data within SAP coupled with national 6-monthly mean fuel prices results in two separate sets of calculations running in parallel: one to calculate the SAP and Environmental Impact scores, and another where reference values are kept under review and can change every six months to generate the other metrics on the EPC.

More specific Scottish data could be accessed through the current PCDB system and used for assessments in Scotland. Entering the post code / location into the software is already used to access the different defaults, e.g. in SAP and SBEM, the very different Building Regulations; in RdSAP, different reference age bands and default wall U-values. As already noted in this report, Ofgem collates Scottish gas

and electricity prices on a 6-monthly basis, so Scottish average fuel prices could be built into the PCDB, and used instead of national averages. Oil costs across Scotland are quite different from the average in the UK. A simple adjustment to the climatic base of the SAP calculation, would allow a Scottish SAP to be calculated.

Additionally, a cost file editor similar to that available in the past within the NHER software system would allow improvements costs to be localised by the assessor manually, to the point of being able to provide bespoke reports on potential improvements. Extending this, again in keeping with facilities that were available in the NHER software, localised fuel prices or occupant-specific prices taken from the fuel bill could also be entered into the program, further allowing the report and recommendations to be customised owner or occupier's circumstances without affecting the actual energy efficiency rating. Currently, an assessor is not expected to gather or localised costs, so this approach is likely to need an expansion of skills and competency.

This development could be done so as without affecting the actual energy efficiency rating.

Possible Calculation action:
Develop a Scottish PCDB which all approved software would use when generating Scottish EPCs. This would have data on energy efficiency improvements and fuel prices which reflect the Scottish market.

- **Rationale: improve accuracy**
- **Time frame:** 🕒🕒🕒🕒🕒
- **Cost:** £ £ £ £ £
- **Impact:** ± ± ± ± ±
- **Magnitude:** 🏠 🏠 🏠 🏠 🏠

Possible Reporting action:
All data referenced from the PCDB to produce the various metrics on an EPC should be declared on the lodged document.

- **Rationale: improve accuracy**
- **Time frame:** 🕒🕒🕒🕒🕒
- **Cost:** £ £ £
- **Impact:** ±
- **Magnitude:** 🏠 🏠 🏠 🏠 🏠

Possible Assessment action:
Publish a guide on calculated and tested U-values for non-traditional and 'system built' buildings in Scotland (this is set out in more detail in Section 6.1.11).

- **Rationale: improve accuracy / improving consistency**
- **Time frame:** 🕒🕒🕒🕒🕒
- **Cost:** £ £ £ £ £
- **Impact:** ± ± ± ± ±
- **Magnitude:** 🏠

6.3.4 Occupancy factors

Issue:
EPC process does not take account of the differences in how dwellings are occupied and how energy is consumed.

Analysis:
Where the policy purpose of an EPC is primarily about improving energy efficiency in the building, the current asset rating approach is, with some adjustments to better reflect the Scottish built environment, a practical solution. If the intention is to engage with owners and occupiers to inform them of their fuel costs or environmental impact, then the EPC process needs to account for the differences in how buildings are occupied and how energy is consumed, beyond that included in the SAP rating.

Occupants affect energy consumption. An operational rating accounting for behaviour could be developed which an assessor selects in order to create the occupancy rating e.g. single occupancy working couple, elderly couple, 2 adults – 2 children etc. This could be further tuned with specific data where known.

A methodology akin to the Green Deal Occupancy Assessment process could be developed to assess real data impacts and to correct for the performance of measures. If EPC output can be affected by occupancy factors, then there will undoubtedly be confusion and perhaps even abuses, thus, keeping these functions separate appears a prudent way forward. EPC assessors will need to be upskilled, in the same way that GDOA were, to account for occupancy factors.

Possible Reporting action:
Use the EPC data to provide tailored advice and support to householders by developing a parallel reporting process.

- **Rationale: improve reporting / recommendations**
- **Time frame:** 🕒🕒🕒🕒🕒
- **Cost:** £ £ £ £ £
- **Impact:** ± ± ± ± ±
- **Magnitude:** 🏠🏠🏠🏠🏠

6.4 Topic: Non-domestic Buildings

- benchmarking
- new technologies
- performance gap
- real data
- recommendations
- review & update
- alternative model
- surveyor skills

6.4.1 Benchmarking

Issues:
Benchmarking requires the availability of energy consumption data that can then be used to prioritise measures/actions.

Analysis:
It can be difficult to make comparisons between different sectors. Barriers to energy efficient retrofits (e.g. insulation) are more significant than for dwellings. A number of responses signposted to recent publication articles and methodologies from other countries. A preference was indicated for operational ratings rather than asset ratings and a suggestion made for funding of longer-terms measures for older buildings.

Benchmarking data can be useful though should be used with care as it is possible to inadvertently compare dissimilar buildings or situations. The use to which the data would be put would also need careful consideration, especially if, for example, used as a basis of comparison for funding purposes. The stated preference for operational ratings (as per Display Energy Certificates (DECs) in other regions of UK) would introduce additional areas of uncertainty in terms of occupant behaviour and occupancy periods. Non-domestic EPCs in Scotland already carry information on the rating that the building would have achieved if built to current building regulations standards (or if subject to the England & Wales ratings calculation) while those in England and Wales also carry information on typical ratings for building stock of the same type.

Possible Reporting action:
Include operational ratings on EPCs in addition to asset rating. Include more comparators (e.g. typical figures for building stock, or at least the building archetype).

- **Rationale: improve reporting / recommendations**
- **Time frame:** 🕒🕒🕒
- **Cost:** £ £ £
- **Impact:** ± ± ± ± ±
- **Magnitude:** 🏠 🏠 🏠 🏠 🏠

6.4.2 Real Data

Issue:
Local authorities should publish real-time data showing energy consumption in their buildings to provide a resource for benchmarking.

Analysis:
Energy consumption data is widely collected and available within local authorities and could be made more widely available. Many public buildings are required to display EPCs though in Scotland these are still asset ratings rather than operational ratings as applied to public buildings in the rest of the UK.

Possible Data Base action:
Produce and publish a database of EPCs and operational energy consumption for all public buildings in Scotland

- **Rationale: improve accuracy**
- **Time frame:** 🕒🕒🕒
- **Cost:** £ £ £
- **Impact:** ± ±
- **Magnitude:** 🏠 🏠 🏠 🏠 🏠

6.4.3 Performance Gap

Issues:
It is difficult to compare energy efficiency and heat decarbonisation performance between different commercial buildings.

Analysis:
EPCs refer to building energy only and not, for example, process energy or electric car-charging points. EPC recommendations cannot simply be translated into costs and actions and enhanced energy audits are needed.

Respondents raised the issue of the disparity between estimated energy consumption (as calculated by SBEM and represented on EPCs) and actual energy consumption of buildings. This is explained by a number of factors including: assumptions and estimations within the SBEM model that are not borne out in reality; the fact that SBEM does not take into account all energy end-loads in a building (e.g. process energy); in short, the differences between an asset rating (for the building) and an operational rating.

Possible Assessment action:
Require more detailed energy audits as the basis for funding decisions.

- **Rationale: improve accuracy**
- **Time frame:** 🕐
- **Cost:** £
- **Impact:** ± ±
- **Magnitude:** 🏠🏠🏠

Possible Reporting action:
Publish operational as well as asset information on EPCs.

- **Rationale: improve reporting and recommendations**
- **Time frame:** 🕐🕐🕐
- **Cost:** £ £
- **Impact:** ± ±
- **Magnitude:** 🏠 🏠 🏠

6.4.4 Recommendations for Non-domestic buildings

Issues:
A robust business case requires actual performance data and real costs.

Analysis:
Requirements for mandatory carbon reporting are trigger point for the energy performance assessment and budgeting. There can be a significant difference between EPC recommendations and guide costs and viable works and costs once on site. Where an ESOS report has been produced this may provide more reliable figures for potential energy savings but does not cover capital costs.

An EPC should not be used as the basis for a works specification especially regarding capital costs. Normal practice would suggest that at least 3 quotes should be obtained for capital works. The non-domestic EPC however should be more reliable in terms of recommendations than the domestic equivalent as the non-domestic assessor is able to add, edit and remove recommendations as they see fit.

This issue has, in part been addressed through the introduction of the Action Plan required where buildings are subject to the Assessment of Energy Performance of Non-domestic Buildings (Scotland) Regulations 2016. The Action Plan requires a 'Section 63 Advisor' to produce a list of tailored recommendations for improvement of a building subject to these regulations. This additional process recognised the limited benefit that can be derived from the generic recommendations that

accompany the vast majority of non-domestic EPCs and the need for further advice if considering improvement.

Possible Reporting action:
A note should be added to the EPC that EPCs should not be used as the basis for works specifications or costs without further more detailed assessment.

- **Rationale: improve accuracy**
- **Time frame:**
- **Cost:** **£**
- **Impact:** **± ± ±**
- **Magnitude:**

6.4.5 Alternative Models

Issues:
There are many commercially available dynamic simulation models that can be used to assess the energy performance of new and existing non-domestic buildings.

Analysis:
While it is certainly the case that alternative models exist, including dynamic thermal models, this is out with the scope of this report.

No further action:
Alternative models were not within the scope of this report, though they may be a worthy subject for future consideration.

6.4.6 New Technologies

Issues:
SBEM is behind the times with regard to new technologies.

Analysis:
The SBEM model on which most non-domestic EPCs are based can represent new technologies such as solar PV, solar thermal, wind, biomass, biofuels, CHP, transpired collectors, waste heat recovery, though not micro-hydro, nor free cooling technologies.

There is certainly scope for enhancing SBEM to be able to cater for such technologies though this would probably require edits to the methodology as well as the interface and would be outwith the scope of this report.

Possible action:
Contact BRE/UK Government department to determine whether there are any plans to increase the range of new technologies catered for in SBEM.

- **Rationale: improve accuracy**
- **Time frame:** 🕒🕒🕒
- **Cost:** **£ £ £**
- **Impact** **± ± ± ± ±**
- **Magnitude:** 🏠 🏠 🏠

6.4.7 Review and Update

Issues:
The current concept of EPCs is sound, as is that of DECs using real data – should they not be combined into one certificate in the future.

Analysis:
There is a consensus of opinion from the workshops that EPCs for existing buildings should include an operational rating as well as an asset rating. It appears to be confusing with the introduction of the Section 63 requirements that there will be 2 very different rating certificates on some non-domestic buildings. The rationale was that the headline figures would more closely represent actual operation of the building which could be important if, say, the EPC were being used for estimating savings/grant eligibility etc. The asset rating is still useful in being able to make a comparison between different buildings of the same type on the same basis.

Combining the asset and operational ratings would require amendments to the interface and output though minimal amendments to the methodology.

Possible Calculation action:
Amend the EPC generator module to allow input of operational energy data such as used in DECs in other parts of the UK.

- **Rationale: improve accuracy**
- **Time frame:** 🕒🕒🕒
- **Cost:** **£££**
- **Impact:** **± ± ±**
- **Magnitude:** 🏠🏠🏠

6.4.8 Surveyor Skills

Issues:
Non-domestic assessors need a higher skill set that domestic building assessors because of the size and specialist purposes of many non-domestic buildings.

Analysis:
This is a positive observation as it means non-domestic assessors are more likely to be suitably experienced and trained in the use of the software and production of EPCs. There were no negative consultation responses regarding non-domestic assessors.

No further action.

6.5 Topic: Assessors

- Starting point
- Surveyor skills
- Quality assurance procedures
- Quality assurance: consistency
- Integrity
- Independence
- Accountability
- Quality Assurance: Improvements

6.5.1 Starting Point

The starting point here was the public expressions of concern across a range of issues involving Assessors. These issues were less about technical concerns with the methodology or the software and more about gaps in the Quality Assurance processes and questions about the competence and independence of assessors. These issues are integral for public confidence and its buy-in to the EPC framework – assessors have to be seen as skilled and independent, the quality assurance procedures have to be seen as robust and consistent in the outcomes, and the system has to be accountable.

6.5.2 Surveyor Skills

Issue:
Respondents raised concerns about the level of training and qualifications of EPC assessors, and noted that there should be a higher level of qualifications and accreditation of assessors.

Analysis:
The high number of responses pertaining to surveyor skills identified in this project was in part a direct consequence of the format of the PRS consultation document: the consultation specifically included questions about surveyor skills and the need for additional qualifications[115] - 144 of the 206 responses identified here were directly related to replies to these questions. The broad consensus of the PRS consultation responders (i.e., 71% overall and 86% of those responding to this question[116]) was that it would be useful to have a traditional buildings qualification on energy

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[115] In *"Energy efficiency and condition standards in private rented housing – A Scotland's Energy Efficiency Programme Consultation"* published by the Scottish Government in April 2017, Question 1.12 in the consultation stated: "We propose to develop a new role of minimum standards assessor … (b) … what additional skills beyond those of an EPC assessor would be needed? (p34). Question 1.16 asked "Do you think it would be helpful for assessors and installers to have a traditional buildings qualification that raises awareness and understanding of energy efficiency measures for older, traditional or vulnerable buildings built prior to 1919?" (p38)

[116] *Energy efficiency and condition standards in private rented housing: Analysis of responses to the public consultation exercise (published November 2017) available at* http://www.gov.scot/Publications/2017/11/6863

efficiency. On traditional buildings, it is not that additional qualifications and courses do not exist already[117], rather it is more the issue that there is currently no requirement for a person to gain such qualifications under current accreditation schemes to qualify as an EPC assessor.

There are two separate issues to address here. The first issue concerns whether current EPC assessors are sufficiently skilled to do the existing job. They should be - the accreditation schemes have all signed protocol agreements with the Scottish Government that include for the training and certification of assessors, Continuing Professional Development training, and quality assurance monitoring that are intended to ensure that current EPC assessors meet a minimum skill standard. Certainly, the consultation responses indicate they are less than convinced that this is the case. During the workshops, a number of participants cited anecdotes of lodged EPCs that failed to correctly identify building components or reflected a lack of care during the survey. Possible actions to address this issue will be explored below under the issue of quality assurance procedures.

The second issue raised concerns that in going forward with promoting energy efficiency as a national infrastructure priority there was a need to develop further skills. The Scottish Government could promote the development of a higher qualified, broader skilled, more professional EPC assessor generally. This approach could include more than additional qualifications on traditional buildings, for example, including a number of additional modules on other building constructions, renewable technologies, insulation specifications, and sizing heating systems amongst other modules. As part of this development, regulation of EPC assessors could move from the various accreditation schemes to one professional body, for example, an EPC assessor associate membership of RICS. This development could be phased in over several years to allow existing surveyors to upskill and meet the new accreditation requirements.

Possible Assessment action:
Explore with SQA and RICS the development of a higher-qualified, broader-skilled, more professional EPC assessor.

- **Rationale: improve consistency**
- **Time frame:** 🕛🕛🕛🕛🕛
- **Cost:** £ £ £ £
- **Impact:** ± ± ±
- **Magnitude:** 🏠 🏠 🏠 🏠 🏠

[117] Historic Environment Scotland already offer such courses, for example, see https://www.engineshed.scot/learning/diploma/unit-1-conservation-in-context/sustainability-and-adaptation-in-the-historic-environment/

6.5.3 Quality Assurance Procedures

Issue:
Respondents felt the current system of quality assurance checks completed by the accreditation schemes in Scotland is inadequate to ensure that a consistent and accurate EPC rating is being achieved by anyone who carries out an assessment.

Analysis:
In Scotland, the Scottish Government set the overall framework with regard to production of EPCs and entered into formal protocol agreements with a number of accreditation schemes (known as Approved Organisations). It was left to these Approved Organisations to set the requirements for their members with regard to quality assurance procedures, amongst other things. While the specific arrangements vary, the different schemes more or less follow the same process: for EPC assessments selected for quality assurance checking, the assessor is requested to submit the supporting documentation which is then checked by the accreditation scheme. This check is a completely desk-based exercise, and is good as far as it goes for correcting visible mistakes in the survey or the data entry, or the interpretation of conventions. While the assessor has to submit supporting evidence (e.g. photographs) of items included in the assessment, items that are missed out may never be picked up, because they were not included in the documentation. On-site, independent follow up assessments are not included as part of the EPC quality assurance procedures.

After a pilot study in 2016[118], 'Smart Auditing' was introduced in England and Wales on June 1st, 2018. This is a 'risk based' audit based on a defined set of rules, whereby an EPC is selected for audit if it breaches a 'smart audit' rule[119]. However, the 'smart audits' are still a desk-based exercise, and are not in addition to current accreditation schemes' quality assurance targets, but will be included within their requirement to audit 2% of lodged EPCs.

The Sustainable Energy Agency of Ireland, which runs the equivalent to the Scottish EPC scheme in the Irish Republic, initially relied on desk audits to monitor 2% of assessors' work. Concerns over the quality of completed assessments led them to introduce a national examination in national test centres on top of the training qualification (which has to be re-sat every two years), and the introduction of a system of external independent audits, with auditors going out on site to re-visit assessments or carry out assessments in tandem with assessors. This audit scheme includes penalty points; the more serious the mistake the more penalty points imposed, with 12 points incurring a suspension, and multiple suspensions revoking registration. The combined result of the repeated national examination (and the

[118] see http://www.ecmk.co.uk/wp-content/uploads/2016/03/Smart-auditing-trial-overview.pdf for a description of the pilot.
[119] for the smart audit rules, see http://www.elmhurstenergy.co.uk/smart-rules

associated cost of sitting the exam) and the independent auditing has resulted in a significant drop in the number of registered assessors in Ireland[120].

Requiring independent back checks would be in keeping with other schemes where quality assurance is considered paramount. Under the Scottish House Condition Survey procedures, independent back check surveys are carried out on a percentage of every surveyor's work as part of the quality assurance procedures. Originally 5%, the percentage has dropped with the introduction of other data validation systems. Under ECO, ECO2 and ECO2T, Ofgem required the utilities to include an independent re-inspection of at least 5% of all jobs, not only to ensure the quality of the work completed, but also on the initial survey data.

Possible Assessment action:
Undertake a research exercise to determine how many EPCs issued under RdSAP 2012 v9.92 breached the 'smart audit rules'.

- **Rationale: improve accuracy**
- **Time frame:** 🕐
- **Cost:** £ £ £
- **Impact:** ± ± ± ± ±
- **Magnitude:** 🏠 🏠 🏠 🏠 🏠

Possible Assessment action:
Introduce 'smart auditing' as part of the Approved Organisations' quality assurance targets in Scotland.

- **Rationale: improve accuracy**
- **Time frame:** 🕐
- **Cost:** £
- **Impact:** ± ± ± ± ±
- **Magnitude:** 🏠 🏠 🏠 🏠 🏠

[120] From a high of about 2,500 assessors in Ireland in 2009/10, there are now in June 2018 only 493 registered BER assessors (see https://ndber.seai.ie/Pass/assessors/search.aspx)

Possible Assessment action:
Introduce the requirement that the quality assurance procedures include independent on-site re-inspections.

- **Rationale: improve accuracy**
- **Time frame:** 🕒🕒🕒
- **Cost:** £ £ £ £ £
- **Impact:** ± ± ± ± ±
- **Magnitude:** 🏠 🏠 🏠 🏠 🏠

Possible Assessment action:
Establish an independent regulator (or vest it within Scottish Government) to oversee the independent re-inspection of EPC assessments, and to report annually on the results.

- **Rationale: improve accuracy**
- **Time frame:** 🕒🕒🕒
- **Cost:** £ £ £ £ £
- **Impact:** ± ± ± ± ±
- **Magnitude:** 🏠 🏠 🏠 🏠 🏠

6.5.4 Quality Assurance: Consistency

Issue:
Different assessors give different results.

Analysis:
Within RdSAP, it is conceivable that different assessors could produce SAP scores for the same property that did not match, or that the same assessor could produce varying SAP scores for the same property. Within RdSAP, there are some data inputs that allow the assessor discretion over whether to use the defaults within the methodology or to input more detailed information (e.g., as discussed in Section 5.5 on rooms in the roof and Section 5.8 on windows). There are also a few items where there is a degree of subjectivity (e.g. whether the kitchen is a habitable room or not). Assessments need to be shown to produce the same, or at least very similar, results, regardless of the assessor involved. This level of assurance will be even more important if associated with financial incentives for energy efficiency improvements and/or regulation to minimum standards of energy efficiency.

If the results are markedly different, then something is wrong. As with the quality assurance procedures discussed above, the Scottish Government has left it to the accreditation schemes to set their requirements with regard to qualifications, including the requisite training. There is no single training standard applied to EPC

assessors in Scotland. Unlike England and Wales, and the Irish Republic, there is no 'national examination' for EPC assessors either.

A large number of workshop participants supported the need for a single recognised standardised qualification to be implemented in Scotland, rather than the variety of different training schemes and qualification standards promoted by individual approved organisations; one training course – one qualification, with on-site visits, based on National Occupational Standards that accurately reflected needs of the vocation and working in the Scottish dwelling stock.

Possible Assessment action:
The Scottish Government in conjunction with SQA to identify and introduce Scottish qualifications, based on National Occupational Standards, for EPC assessors, for existing dwellings, new build dwellings, and non-domestic dwellings. Part of this qualification would be the potential assessor successfully completing a national examination.

- **Rationale: improve accuracy / improving consistency**
- **Time frame:** 🕒🕒🕒
- **Cost:** £ £ £ £ £
- **Impact:** ± ± ± ± ±
- **Magnitude:** 🏠 🏠 🏠 🏠 🏠

Possible Assessment action:
All SAP, RdSAP and SBEM training courses being offered in Scotland, and the respective trainers, should be vetted with regard to their competence and the experience of the trainers. These items should not be left in the hands of the accreditation Schemes.

- **Rationale: improve accuracy / improving consistency**
- **Time frame:** 🕒🕒🕒
- **Cost:** £ £ £
- **Impact:** ± ± ± ± ±
- **Magnitude:** 🏠 🏠 🏠 🏠 🏠

6.5.5 Quality Assurance: Integrity

Issue:
Respondents raised concerns about the integrity of some EPC assessors with a perception that they may be deliberately changing data or making recommendations for financial gain**.**

Analysis:
There is a significant degree of difference between a situation where an assessor makes a mistake and misses out some control or wrongly identifies a wall construction, and that where an assessor or company routinely or deliberately misrepresents the data for financial reward. If the quality assurance procedures are adequate then 'honest' mistakes will be picked up and corrected, and the assessor will learn. If data is being misrepresented routinely, then the quality assurance procedures may pick up the issue, but as the quality assurance procedures are only 2% desk audit of EPCs, an unscrupulous assessor or company may accept that this risk is financially worthwhile. For some types of misrepresentation, for example claiming a filled cavity wall as unfilled to attain a better carbon saving and a higher profit from [supposedly] filling it, may be facilitated by not submitting any photographs showing an existing drill pattern as part of a quality assurance audit.

Where repeated misrepresentation of data is found, sanctions exist so that assessors or companies can be suspended or ultimately de-registered from the EPC process. The Department of Energy and Climate has suggested with regard to the Green Deal, "that as many as 11% of Green Deal assessors and 14% of Green Deal installers were suspended by the change due to 'non-compliance with Green Deal scheme requirements."[121] However, respondents felt that these sanctions are seldom used (if at all). As one workshop participant noted "In the insulation industry I have not heard of any EPC assessor or PAS2030 contractor being suspended or losing their accreditation or being fined" – name and shame.

Possible Assessment action:
The Scottish Government to agree with the Accreditation Schemes rules and procedures for suspending and de-registering assessors or companies that bring the EPC scheme into disrepute by misrepresenting data, and the list of suspended and deregistered are published as part of the list of registered assessors online.

- **Rationale: improve accuracy / improving consistency**
- **Time frame:** 🕒🕒🕒
- **Cost:** £ £ £
- **Impact:** ± ± ±
- **Magnitude:** 🏠 🏠 🏠 🏠 🏠

[121] see Rosenow, J., & Eyre, N. (2016). *A post-mortem of the Green Deal: Austerity, energy efficiency and failure in British energy policy.* Energy Research and Social Science, 21, 141–144.

6.5.6 Independence

Issue:
There is a conflict of interest with insulation companies carrying out EPC assessments that recommend the products they are selling.

Analysis:
Currently, there are no rules preventing insulation companies employing EPC assessors. The recommendations included on the EPC are a direct consequence of Appendix T (see section 5.3). An assessor can remove recommendations from the EPC. However, unlike the Green Deal and the Green Deal Advisory Report, an EPC assessor cannot add recommendations to the EPC report. The EPC assessor could not change the order of the recommendations or the payback return on the EPC. All of these items are governed by Appendix T or embedded within the PCDB which are beyond the scope of the EPC assessor to edit.

Currently, as part of the lodgement of an EPC, the assessor is required to indicate any third party interest, though working for an insulation company is not one of the categories currently that must be declared. Unless this is seen as a problem, then no further action is needed.

No further action.

6.5.7 Quality Assurance: Accountability

Issue:
There is no mechanism in place to allow a home owner or landlord to challenge an EPC assessment.

Analysis:
In the current EPC format, there is only a summary of the information about the dwelling assessed included in the EPC report. If a householder or landlord is unhappy with the EPC rating, or believes that the data used in the assessment is incorrect, this mistake might be quite obvious, e.g. where the type of heating is completely wrong. In many instances the EPC report does not provide enough detail to confirm or disprove this belief. For the sake of transparency then, the survey data used in the assessment should be made available to the householder or landlord.

One method of doing this would be to reformat the EPC to include the input data, and possibly photographic evidence. An alternative approach would be to not only upload the EPC onto the national register but also the summary data. As far as the authors are aware, all of the approved EPC software packages for use in Scotland produce a summary report of the data included in the assessment. This summary report could be uploaded into the national register at the same time as the EPC is lodged, and the summary report could be made available online alongside the EPC report.

Possible Data Base action:
Require the summary data report to be lodged on the national register alongside the EPC, and to make this summary report available online alongside the EPC.

- **Rationale: improve reporting / recommendations**
- **Time frame:** 🕐🕐🕐
- **Cost:** £ £ £ £ £
- **Impact:** ± ± ±
- **Magnitude:** 🏠 🏠 🏠 🏠 🏠

6.5.8 Quality Assurance: Improvements

Issue:
There is no system of quality control on the improvements carried out on a property as a result of an EPC recommendation.

Analysis:
An EPC may make a recommendation but the quality of any resultant works completed is an issue for the building owner or landlord and the installer and the various certification schemes governing the work. This concern falls outwith the scope of EPCs.

No further action.

6.6 Technical Issue: Room in the Roof Dwellings

- Starting Point
- The Use of Defaults: Consistency
- The Use of Defaults: U-values
- The Use of Defaults: Accuracy
- Cost of Improvements

6.6.1 Room in the Roof Dwellings: Starting Point

The starting point for examining the treatment of rooms in the roof within RdSAP was expressed concerns that the rooms in the roof within dwellings are not reliably accounted for within the EPC process. These concerns touched upon the collection of data on the room in the roof (i.e. the assessor consistency), the modelling of the energy performance (i.e. defaults, U-values, and accuracy), through to the costing of improvements recommended on the EPC (i.e. the use of the PCDB). There is a great deal of overlap amongst several of these issues.

6.6.2 Room in the Roof Dwellings: The Use of Defaults: Consistency

Issue:
It is left to the assessor's discretion when to carry out detailed measurements of rooms in the roof, leading to inconsistencies between EPC assessments for the same dwelling.

Analysis:
Entering the dimensional data into SAP and RdSAP are two distinctly different processes. A full SAP analysis of a property requires the assessor to calculate the dimensional data for each fabric component within a dwelling, and to calculate the respective heat loss U-value for each different fabric component. While the full SAP methodology underlies RdSAP, RdSAP utilises a geometric model for calculating the fabric dimensional data, and defaults for assigning the U-values to their heat loss. As an asset rating, RdSAP is trying to combine accuracy and consistency through published conventions for assessors to follow when collecting the data, and when entering it into the approved software. The aim was to keep measurements as simple and straightforward as possible.

Rooms in the roof are a particular case in point. It was recognised that rooms in the roof could be complicated, and their measurement time consuming. In early field trials of RdSAP, wide inconsistencies were found amongst surveyors' room in the roof measurements. As a result, algorithms were developed to calculate the room in the roof fabric components' areas derived from the total room in the roof floor area. "Consistency was more important than accuracy[122]". Between 2009 and 2012,

[122] Stuart Fairlie, Elmhurst Energy, email correspondence after Edinburgh workshop

RdSAP only required three data entry items: the age band of the room in the roof, its total floor area, and the thickness of any observed insulation.

In 2012, RdSAP was modified to allow for extended data entry for rooms in the roof, i.e. to be more in keeping with a full SAP assessment, as dimensional data and U-values could be calculated for each room in the roof fabric component[123]. The RdSAP Conventions were modified to define when the extended data option was required to be used for an assessment. For the most, few instances specifically required detailed measurements, and it was left to the discretion of the assessor to turn on extended data entry within RdSAP.

Recent changes to the wording of the convention on rooms in the roof (see Supplementary Topic Note 3 on Rooms in the Roof for further elaboration) has resulted in the text of Appendix S and the current conventions[124] not being consistent with one another. Further, the recent changes also appear to require more frequent measurements of roof rooms (again, see Supplementary Topic Note 3 on Rooms in the Roof for further elaboration).

The current convention reads:
*"Detailed measurements of all elements **are required only** if evidence exists that the flat roof/slope/stud wall/gable walls have different levels of insulation or their U-values are known."*[125]*(emboldment added)*

Given that many RdSAP assessors are not qualified under the RdSAP conventions to over-write the default U-values within the software, the caveat that detailed measurements are only required if the U-values are known limits the number of occasions when detailed measurements will be required. By contrast, the various components of the room in the roof often have differing levels of insulation. Are detailed measurements required in these instances? If so, then this requirement will significantly increase the number of occasions when detailed measurements are required, defeating the aim to keep measurements as simple and straightforward as possible.

Views expressed by workshop participants reflected the confusion amongst assessors:

- *"that the guidance is not clear – unambiguous procedures need to be provided";*
- *"the [Rd]SAP guidance and accreditation schemes guidance not clear enough on what measurements and inputs that are required";*
- *"too complicated to understand when to measure";*

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[123] Extended room in the roof data was enabled in RdSAP 2009 v9.91 and all versions since.
[124] Convention 2.06 in "Conventions (v 10.0) for RdSAP 9.92 and RdSAP 9.93" available at https://www.bre.co.uk/filelibrary/SAP/2012/RdSAP-Conventions-10_0---from-31-December-2017.pdf
[125] [125] Taken from "Conventions (v 10.0) for RdSAP 9.92 and RdSAP 9.93" available at https://www.bre.co.uk/filelibrary/SAP/2012/RdSAP-Conventions-10_0---from-31-December-2017.pdf

- *"more definitive definition of … what exactly is to be measured"*

Nobody stated that the guidance and conventions were clear and unambiguous.

Possible Assessment action:
The convention on rooms in the roof should be re-written to provide clear, unambiguous and definitive guidance on when detailed room in the roof measurements are required.

- **Rationale: improve accuracy / improving consistency**
- **Time frame:** 🕐🕐🕐
- **Cost:** £ £ £
- **Impact:** ± ± ±
- **Magnitude:**

6.6.3 Room in the Roof Dwellings: The Use of Defaults: U-values

Issue:
RdSAP does not adequately account for the heat loss through rooms in the roof.

Analysis:
The U-values assigned to the individual room in the roof components in RdSAP are a function of the period when the room in the roof was constructed and the levels of insulation that can be identified during the survey. The resultant default U-values are defined in Appendix S of the SAP Manual.

Unfortunately, the requirement for evidence of the levels of insulation of the different room in the roof components is often denied to assessors by the very construction of the room of the roof: the level of insulation cannot be seen. Without requiring intrusive surveys, default U-values are needed in many room in the roof assessments.

While default U-values may be appropriate for 'uninsulated' rooms in the roof, or those constructed to a specific set of Building Regulation standards, it may not be sufficient for refurbishment improvements. Insulating a room in the roof is one area where, when the work is completed, visible evidence may not be available. As already discussed in section 5.2.14 above, the EPC process needs to develop to take account of insulation improvements where visible evidence is not available on completion of the works.

Possible Assessment action:
Develop procedures to take account of insulation that cannot be seen. This could include adding an addendum to the data entry that the U-values take account of insulation that has not been accompanied by the current standard of documentary evidence.

- **Rationale: improve accuracy / improving consistency**
- **Time frame:** 🕒🕒🕒
- **Cost:** £ £ £
- **Impact:** ± ± ±
- **Magnitude:** 🏠

Possible Assessment action:
Develop a household log book akin to the benchmark log book for boilers in which contractors would sign off insulation improvements completed in a dwelling.

- **Rationale: improve accuracy / improving consistency**
- **Time frame:** 🕒🕒🕒
- **Cost:** £ £ £
- **Impact:** ± ± ± ± ±
- **Magnitude:** 🏠 🏠 🏠 🏠 🏠

Possible Data Base action:
Develop a database alongside the EPC register to upload PAS2030 certificates of compliance that can be accessed by householders and assessors to check if insulation has been installed.

- **Rationale: improve accuracy**
- **Time frame:** 🕒🕒🕒
- **Cost:** £ £ £ £ £
- **Impact:** ± ± ±
- **Magnitude:** 🏠 🏠 🏠

6.6.4 Room in the Roof Dwellings: The Use of Defaults: Accuracy

Issue:
Rooms in the roof are not reliably accounted for in RdSAP.

Analysis:
As discussed above in section 5.5.5, algorithms within the RdSAP methodology calculate the room in the roof fabric components' areas from the total room in the roof floor area. The formulae effectively create a box room (see the Supplementary Topic Note 3 on Rooms in the Roof); the more the shape of the room in the roof deviates from this box shape, the greater the discrepancy between the actual component dimensions and those modelled.

One solution here would be to require full dimensional data for all room in the roof components. This approach has already been trialled and found wanting. An alternative approach would be to continue to utilise algorithms built into the RdSAP software to calculate the dimensional components but to have more of them[126]. Rather than entering only the total room in the roof floor area, the assessor would also select from the convention images the one that most closely matched the room in the roof arrangement of the surveyed dwelling, and the program would calculate the component dimensions. Importantly, this would also allow "half-wall" or 1.5 storey dwelling common walls to be treated differently from the stud walls built into the attic space (again, see Supplementary Topic Note 3 on Rooms in the Roof).

The workshop discussion revolved around whether there was ever a need for any dimensional measurements other than the total floor area. For many room in the roof structures, the impact of the extended data entry dimensions is marginal in terms of the rating. What appears to be more important is the level of insulation.

The presumption should not be that all roof room components are insulated to the same extent; the insulation of each component of the roof room structure should be identified and entered into the room in the roof data entry if possible. Like the main dwelling, this should be based on the thickness of the insulation that can be identified, and not from 'calculated' U-values. This would be consistent with the view expressed above that the "roof room data survey should be made more easy and repeatable". More comparative work is needed on this topic.

If a more detailed energy assessment of a dwelling is required, and in particular, the roof room components, then an assessor could opt to enter extended data, but this would not be required for the asset rating.

[126] The NHER Surveyor 3 model utilised four default room in the roof shapes in calculating the components of the room in the roof. While the RdSAP conventions display different room in the roof shapes, the algorithm ignores the shape when calculating the dimensional data of the components.

Possible Calculation action:
Develop more algorithms for default room in the roof shapes. The conventions would need to be amended accordingly.

- **Rationale: improve accuracy**
- **Time frame:** 🕐🕐🕐🕐🕐
- **Cost:** £ £ £ £ £
- **Impact:** ± ± ± ± ±
- **Magnitude:** 🏠 🏠 🏠

Possible Calculation action:
Redefine half-wall type dwellings within RdSAP. The conventions would need to be amended accordingly.

- **Rationale: improve accuracy**
- **Time frame:** 🕐🕐🕐🕐🕐
- **Cost:** £ £ £ £ £
- **Impact:** ± ± ± ± ±
- **Magnitude:** 🏠 🏠 🏠

6.6.5 Room in the Roof Dwellings: The Cost of Improvements

Issue:
The costs associated with improving a room in the roof structure as shown on the EPC are highly inaccurate.

Analysis:
The costs associated with carrying out room in the roof improvements are embedded within the PCDB used by the RdSAP program. These issues are discussed more fully in Section 5.3.

No further action.

6.7 Technical Issue: District and Community Heating / Combined Heat & Power

- Starting Point
- Accuracy
- Use of Defaults
- Appendix T
- PCDB / Real Data
- Metric / Alternative Models / Mapping

6.7.1 DH/CHP Starting Point

The starting point of this topic was the concern that the benefits of DH/CHP are not fully recognised within the RdSAP methodology; and that methodological and software constraints in respect of DH/CHP need to be addressed if RdSAP is going to support DH/CHP and its role in supporting the development of local heat networks and shaping Scotland's energy future by the year 2032.

6.7.2 DH/CHP Accuracy

Issue:
DH/CHP systems are not accurately accounted for within RdSAP. The input data associated with RdSAP is very limited.

Analysis:
In RdSAP, DH/CHP systems are entered into the software via only four considerations:

- **the heat source**: boilers / CHP / heat pump
- **the system fuel**: mains gas / LPG / oil / mineral oil or biodiesel / biodiesel from any vegetable source / biodiesel from vegetable oil only / B30D / coal / biomass / electricity / waste combustion / biogas / waste heat / geothermal heat source
- **the main heating controls**: none / programmer only / room thermostat only / TRVs only / programmer and Room thermostat / programmer and TRVs / two or more room thermostats
- **the method of charging for consumption**: whether flat rate charging or consumption-based charging

Significantly more system specific data is needed in a full SAP assessment. Compared to RdSAP, a full SAP assessment of the same systems would require data inputs on up to 10 variables (see Supplementary Topic Note 4 on Community Heating for a more detailed discussion on the data needs). The differences in the number of inputs are reflected in the outputs of the two programs.

A comparative case study (see Supplementary Topic Note 4 on Community Heating) comparing the differences in the outputs of a RdSAP assessment and a full SAP assessment of the same 13 flats[127], found that the RdSAP results ranged between 1 and 5 SAP points lower than those produced by the full SAP analysis; that RdSAP estimated fuel bills[128] were between £16 and £119 more over a year than those estimated by the full SAP assessment; and that RdSAP estimated CO_2 emissions to be between 0.54 to 1.52 tonnes more per year that the full SAP assessment. When aggregated across the whole of the 55 flats within the multi-storey block, and compared to the full SAP assessment results, RdSAP over-estimated the CO_2 emissions by 41,909 tonnes per year; over-estimated the fuel bills by £3,337 per year; and over-estimated the space heating consumption by 7,791 kWh per year.

The differences in the results between a RdSAP and a full SAP assessment of the same flats connected to a DH/CHP system suggest one of two possible courses: either incorporating the full SAP DH/CHP system data entry items into the RdSAP methodology, with appropriate conventions and defaults when the information is not available, or requiring a full SAP assessment when a dwelling is connected to a DH/CHP system.

Not all workshop participants were happy with either option:

- *"I do not think that RdSAP is an appropriate tool for assessing DH/CHP schemes. DH/CHP should be investigated as a stand-alone exercise".*
- *"Rather than fit DH/CHP into SAP or RdSAP, it may be more appropriate for future developments that SAP/RdSAP assessments are fitted into the models used by the major engineering companies to design DH/CHP schemes."*
- *"DH/CHP affects a very small percentage of the Scottish dwelling stock: such a small number of properties are affected that it does not warrant a change".*
- *Leave current average DH /CHP efficiency as is. I do not want to collect industrial sized boiler details.*

Possible Calculation action:
Incorporate the full SAP DH/CHP system data entry items into the RdSAP methodology with appropriate conventions and defaults when the information is not available.

- **Rationale: improve accuracy**
- **Time frame:** 🕒🕒🕒🕒
- **Cost:** £ £ £ £ £
- **Impact:** ± ± ± ± ±
- **Magnitude:** 🏠

[127] All input data was matched in the two programs with the exception of the data on the combined heat and power system.
[128] SAP calculated fuel bills only cover space and water heating, lighting, and some standing charges. They do include costs for other fuel use in the home, e.g. cooking and appliance use.

Possible Assessment action:
Require a full SAP assessment when a dwelling is connected to a DH/CHP system.

- **Rationale: improve accuracy**
- **Time frame:**
- **Cost:** **£**
- **Impact:** **± ± ± ± ±**
- **Magnitude:**

No further action:
Developing a stand-alone tool for assessing DH/CHP systems or incorporating the SAP / RdSAP assessments into the models used by the major engineering companies when designing DH/CHP systems - both have merit but are outside the remit of this report.

6.7.3 DH/CHP: Use of Defaults

Issue:
The RdSAP defaults for DH/CHP systems are very limited and poor.

Analysis:
In RdSAP, given the limited data inputs (see the section above); all DH/CHP schemes are assessed primarily from default data built into RdSAP. However, there would appear to be only one default for most of the data entry items, so that all DH/CHP systems are assessed on the basis of the same boiler performance efficiency and fuel prices, regardless of the actual age, efficiency, distribution network, or system fuel. The only item that has variable defaults is the CO_2 emission factor(s) for the DH/CHP fuel source.

If a householder replaces a gas boiler in their home with a more efficient one, then the presumption is that the SAP score improves, but not so with DH/CHP systems. Replacement of ancient DH/CHP boiler plant with modern, more efficient plant has no effect on the SAP score. Not even changing the fuel source for the DH/CHP systems affects the SAP score, unlike switching fuels on individual heating systems. The estimated fuel costs are the same regardless of the fuel source of the DH/CHP system. This is demonstrated in Supplementary Topic Note 4 on Community Heating.

Neither the overall EPC result nor RdSAP outputs are reflective of the actual DH/CHP system installed. This further reinforces the need set out in the section above for either incorporating the full SAP data entry items into RdSAP, or to require full SAP assessments for properties connected to DH/CHP systems.

Two items emerged from the workshop discussions with implications for the defaults used in SAP and RdSAP with regard to DH/CHP:

- Should there be a difference between consumption charging and flat rate charging in DH/CHP? Built into SAP and RdSAP is the default assumption that flat rate charging leads to over consumption. The result is that if the DH/CHP scheme applies a flat rate charge to the occupants for their heating and hot water use, the resultant SAP score is not as good as one calculated where consumption based charging is used, that is, where the more you use, the more you pay. However, should this 'overheating' not be deemed occupant behaviour, which is ignored generally in the SAP / RdSAP methodologies. Electric heat with rent schemes are not treated in a similar fashion.
- In multi-storey buildings connected to DH/CHP systems, with the systems located in the circulation areas, the temperatures can be quite warm, thereby reducing the heat loss from dwelling where they back on to these common areas. While the resultant temperatures may not achieve those in circulation spaces fitted with actual radiators, these spaces are certainly warmer than ambient unheated spaces. Should RdSAP not recognise the heat gains from DH/CHP system risers in the circulation areas?

Possible Calculation action:
Incorporate the full SAP DH/CHP system data entry items into the RdSAP methodology with appropriate conventions and defaults when the information is not available.

- **Rationale: improve accuracy**
- **Time frame:** 🌍🌍🌍🌍
- **Cost:** £ £ £ £ £
- **Impact:** ± ± ± ± ±
- **Magnitude:** 🏠

Possible Assessment action:
Require a full SAP assessment when a dwelling is connected to a DH/CHP system.

- **Rationale: improve accuracy**
- **Time frame:** 🌍🌍🌍🌍
- **Cost:** £ £ £ £ £
- **Impact:** ± ± ± ± ±
- **Magnitude:** 🏠

Possible Calculation action:
Consider possible change to convention on definition of a heated corridor in multi-storey blocks connected to DH/CHP systems where the system risers are in the circulation areas.

- **Rationale: improve accuracy**
- **Time frame:** 🕐
- **Cost:** £
- **Impact:** ±
- **Magnitude:** 🏠

Possible Calculation action:
Consider possible changes to the SAP and RdSAP methodology with regard to 'penalising' flat rate charging.

- **Rationale: improve accuracy**
- **Time frame:** 🕐🕐🕐
- **Cost:** £ £ £
- **Impact:** ± ±
- **Magnitude:** 🏠

6.7.4 DH/CHP: Appendix T

Issue:
The EPC does not recommend connecting to DH/CHP system as a possible improvement option.

Analysis:
Currently, the EPC does not recommend connection to the local DH/CHP even when this is a local possibility. Connection to a DH/CHP system is not defined in Appendix T. (See Section 6.2 for a fuller discussion on Appendix T issues.) To change this situation would require connecting to a DH/CHP system to be added to Appendix T. Additionally, a convention would need to be defined on when to make this recommendation (to prevent the recommendation being made on properties where no such network was present), for example, when a dwelling was within x meters of a distribution network or the dwelling was located in a block where a DH/CHP system was installed. Two areas where this development would seem particularly appropriate are in Lerwick and in parts of Aberdeen where there are existing DH/CHP distribution networks.

Possible Reporting action:
Include for connecting a dwelling to DH/CHP system within Appendix T.

- **Rationale: improve reporting / recommendations**
- **Time frame:** 🕐🕐🕐
- **Cost:** **£ £ £**
- **Impact:** **± ± ± ± ±**
- **Magnitude:** 🏠

Possible Assessment action:
Define a convention on when to make the recommendation to connect to a local DH/CHP system.

- **Rationale: improve reporting / recommendations**
- **Time frame:** 🕐
- **Cost:** **£**
- **Impact:** **± ± ± ± ±**
- **Magnitude:** 🏠

6.7.5 DH/CHP: PCDB / Real Data

Issue:
Better assessments of DH/CHP systems need operational data rather than defaults built into the PCDB.

Analysis:
Even in a full SAP assessment of dwellings connected to a DH/CHP scheme, the assessor needs operational plant data or design data. Site managers or building owners will hopefully be able to help, but often they may not know the efficiency data of the plant. Without the operation data, the assessor is back to relying on the SAP defaults.

The PCDB is attempting to establish a common resource built into the software of operational data on individual DH/CHP schemes to replace defaults. Currently, this resource includes data on one scheme only (although it is a Scottish scheme, i.e. Lerwick).

If local heat networks are going to be rolled out, then a concomitant requirement from the Scottish Government may be needed to force schemes to either supply the operational data to the PCDB, or establish a system akin to the Display Energy Certificates with the operational parameters and affixed on the boiler house door, so

that an assessor could obtain the necessary boiler plant data for the assessment. This would allow the DH/CHP schemes to be modelled more accurately rather than using defaults.

Possible Assessment action:
The Scottish Government could mandate that Display Energy Certificate-type certificates be displayed outside the door on boiler plant setting out the DH/CHP operational efficiencies. This would provide an accessible source of data to the assessor.

- **Rationale: improve accuracy**
- **Time frame:** 🕒🕒🕒
- **Cost:** **£**
- **Impact:** **± ± ± ± ±**
- **Magnitude:** 🏠

Possible Assessment action:
The Scottish Government should encourage DH/CHP system owners to get the operational parameters of their systems added to the PCDB database.

- **Rationale: improve accuracy**
- **Time frame:** 🕒🕒🕒
- **Cost:** **£**
- **Impact:** **± ± ± ± ±**
- **Magnitude:** 🏠

6.7.6 DH/CHP: Metric / Alternative Models / Mapping

The issues raised under these responses (i.e. the impact of DH/CHP on the Building Regulations, the need for alternative models for assessing DH/CHP systems, and mapping heat loads) are outside the scope of this assessment on EPCs.

No further action.

6.8 Technical issue: Ventilation

- Starting Point
- The Metric
- Infiltration Factors
- Air Infiltration Rate Testing
- Improvements

6.8.1 Ventilation: Starting Point

"To limit heat loss, any heated building should be designed to limit air infiltration through the building fabric."[129] Importantly, this limitation should not compromise ventilation for health considerations, removing moisture, the presence of combustion appliances, and smoke control. BS EN ISO 9972:2015[130] sets out a standard for determining the air permeability of buildings via fan pressurisation testing. The results from a fan pressurisation test can be entered into the full SAP program as part of the process for determining new dwelling compliance with the Scottish Building Regulations. If the results of an air pressurisation test are not available, then SAP will estimate the infiltration rate from a number of variables (see Supplementary Topic Note 5 on Ventilation for a more detailed discussion).

Table S5 of SAP 2012 Appendix S describes the factors which will impact on an estimation of the air infiltration rate of a property through RdSAP. However, many of these factors are not data items that the assessor can inform through the survey of a property as they are assumed by the program. An existing dwelling receives no credit in RdSAP for a draught lobby, and adding a draught lobby would never appear as a recommendation. An RdSAP assessor only collects data specifically on three ventilation parameters. The rest are determined from other data by the program, e.g. age of construction determines the number of extract fans.[131]

As part of this project, a comparative exercise was carried out on 183 properties on the impact of replacing known ventilation variables with the RdSAP defaults[132]. Within this sample of dwellings, RdSAP was found to underestimate the ventilation losses overall because it defaults on the presence of a draught lobby, the number of flues and the number of extract fans within a dwelling, and as a result overestimated the SAP and Environmental Impact scores, and underestimated the SAP calculated fuel bill, CO_2 emissions and energy consumption.

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[129] Scottish Building Regulations Technical Handbook 2017 Domestic – Energy, section 6.2.4, p18 available at http://www.gov.scot/Resource/0052/00521754.pdf

[130] BS EN ISO 9972:2015 - *Thermal performance of buildings: Determination of air permeability of buildings: Fan pressurization method* replaces BS EN 13829:2001 specifically cited in the Technical Handbook 2017 Domestic – Energy, Section 6.2.5, p.19

[131] Supplementary Topic Note 5 on Ventilation sets out Table S5 in full.

[132] Ibid. 3

6.8.2 Ventilation: The Metric

Issue:
SAP / RdSAP need to take account of local wind speed.

Analysis:
In areas of the country with high average wind speeds, (e.g. the Hebrides, Orkney, Shetlands, and the Highlands) unwanted ventilation may be a significant factor in a dwelling's heat loss. Interestingly, RdSAP in part accounts for this when it estimates the dwelling's space heating fuel bill, because the program accesses the postcode sector of the PCDB to complete this calculation: each post code sector has its own set of monthly wind speed factors. However, for the SAP assessment, and any associated recommendations, the program ignores local climatic data, and only uses the default UK climatic data. Without changing the underlying basis of the SAP metric, this dichotomy is not going to change.

No further action

6.8.3 Ventilation: Infiltration Factors

Issue:
There are too many assumptions about ventilation within RdSAP. More options are required in the ventilation calculation to take account of poorly fitting windows and doors, retrofitted mechanical ventilation, and extract fans.

Analysis:
In RdSAP, only three ventilation variables are informed by the dwelling assessment and entered directly into the program:

- the percentage of draughtproofed doors and windows;
- the number of open fireplaces; and,
- the presence and type of a mechanical ventilation system[133].

The SAP-RdSAP comparative exercise on ventilation inputs found that switching from the actual ventilation variables in full SAP to the RdSAP defaults resulted in a reduction of the air infiltration rate of 0.08 air changes per hour (that is, a lower ventilation loss) with a consequential 0.62 point increase in the SAP score and 0.55 point increase in the Environmental Impact score. Fuel costs, CO_2 emissions and energy consumption all decreased: an annual saving of £17.81 on the SAP fuel bill; a 107 kg decline in the yearly CO_2 emissions; and an energy consumption of reduction of 535 kWh across the year.

[133] Mechanical ventilations systems are reduced from 6 different system types in full SAP down to one of 2 types in RdSAP, with no additional system descriptors needed, and no PCDF options.

Replacing defaulted ventilation data within RdSAP with actual dwelling data would not add significantly to the time to complete a survey: all rooms are already visited and details noted. Including a count of the number of extract fans, air bricks, and flues, and noting the presence of a draught lobby would be part of this assessment. Allowing this data to replace the RdSAP defaults currently used would not require new ventilation algorithms as they are defined in full SAP already.

A convention in SAP and RdSAP already exists for distinguishing between chimneys and flues; however, there is no convention on scoring air bricks.

Possible Calculation action:
Allow the actual number of extract fans, air bricks, and flues, and the presence of a draught lobby to be entered within RdSAP programs.

- **Rationale: improve accuracy**
- **Time frame:** 🕒🕒🕒
- **Cost:** **£ £ £**
- **Impact:** **± ± ±**
- **Magnitude:** 

Possible Assessment action:
Define a convention in RdSAP for assessing air bricks.

- **Rationale: improve accuracy**
- **Time frame:** 🕒🕒🕒
- **Cost:** **£££**
- **Impact:** **±**
- **Magnitude:** 

No further action:
*T*he condition of window frames or the fitting within the building fabric is not part of the EPC assessment. Air infiltration because of badly fitting windows, or any other breaches of the building envelope, would be better assessed using Air Infiltration testing (see next section).

6.8.4 Ventilation: Infiltration: Air Infiltration Rate Testing

Issue:
RdSAP does not allow for Air Infiltration Test results to be included.

Analysis:
Air Infiltration Rate testing is included within the Scottish Building Regulations under Section 6[134], as part of determining compliance with the regulations. Importantly, the results can be entered into the full SAP program so, rather than estimating ventilation rates, actual measured data is used in the SAP calculation. At least one HEEPS ABS monitoring project is proposing that air infiltration rates are measured as part of the data collection as part of the assessment of the impact of improvement works on existing dwellings[135]. While there should be no requirement that air infiltration rate testing is carried out as part of an RdSAP assessment, given its cost, where the data is available it should be allowed to be used in the RdSAP program, subject to the testing meeting the BS EN ISO 9972: 2015 standard. This would require modifications to the RdSAP software, but the necessary algorithms are already present in the full SAP program.

The requirements for air infiltration rate testing of some new dwellings are nurturing a nascent industry. Allowing the results to be used in the assessment of existing dwellings, through incorporating it into RdSAP, would be additional boon.

Further, for existing dwellings, it would move the consideration of reducing unnecessary air infiltration away from just focussing on the draughtproofing of doors and windows, onto a more holistic and robust assessment of a dwelling's ventilation needs and infiltration rates (see section 5.7.6 below). Testing could also highlight potential problems of existing buildings being made too air tight through fabric improvement measures, and ensure that sufficient ventilation was included within improvement specifications.

Possible Calculation action:
Allow for air infiltration rate test results to be entered into RdSAP.

- **Rationale: improve accuracy**
- **Time frame:** 🕐🕐🕐
- **Cost:** £ £ £
- **Impact:** ± ± ±
- **Magnitude:** 🏠 🏠

[134] See Scottish Building Regulations Technical Handbook 2017 Domestic – Energy, Sections 6.2.4 and 6.2.5 available at http://www.gov.scot/Resource/0052/00521754.pdf
[135] Renfrewshire Council Invitation to Tender: Property Monitoring and Design Support for HEEPS ABS Programme, published 31st May 2018, available at https://www.publiccontractsscotland.gov.uk/search/show/search_view.aspx?ID=MAY320600

Possible Assessment action:
To support the inclusion of air infiltration rate test results within RdSAP, define a convention governing the necessary standards to be met by the tests, the qualifications of those carrying out the tests, and the requisite documentation to support this development. Existing industry standards already exist, and are accepted by the Scottish Government, with regard to testing new dwellings and Building Regulations compliance so could be readily incorporated into RdSAP conventions.

- **Rationale: improve accuracy / improving consistency**
- **Time frame:** 🕐🕐🕐
- **Cost:** £ £ £
- **Impact:** ± ± ±
- **Magnitude:** 🏠 🏠 🏠

6.8.5 Ventilation: Improvements

Issue:
The impact of reducing air infiltration and draughtproofing is not adequately accounted for in RdSAP

Analysis:
Much of this concern appears to revolve around draughtproofing improvements not seeming to appear as recommendations on the EPC.

Both SAP and RdSAP include a wide range of variables within the assessment of a dwelling's ventilation rate. No single ventilation factor on its own is going to make a significant impact on the ventilation rate because of the many variables that contribute to the derivation on the air infiltration rate. Whereas in a full SAP assessment these are all detailed, in RdSAP most are default values.

Draughtproofing is assessed as part of an RdSAP dwelling survey, and is included within Appendix T as a possible improvement recommendation when the level of draughtproofing is less than 100%. Unfortunately, its impact on the SAP score is often going to be less than +0.95 SAP points so it will not appear on the EPC as a recommendation because of the Appendix T rules (see Section 5.3).

Possible Reporting action:
Amend the Appendix T rules so that draughtproofing is included as an improvement recommendation when the level of draughtproofing of the windows and doors is less than 100%.

- **Rationale: improve reporting / recommendations**
- **Time frame:** 🕒🕒🕒
- **Cost:** **£££**
- **Impact:** **±**
- **Magnitude:** 🏠

6.9 Technical Issue: Measuring Windows

- Starting Point
- Measuring Windows
- Window U-values
- Recommendations: Secondary Glazing
- Recommendations: Shutters

6.9.1 Measuring Windows: Starting Point

Glazing-related issues were not identified specifically by many respondents to the public consultations. However, the expressed concerns about inconsistencies between surveyors and the gap between actual energy performance and the modelled performance of a dwelling (discussed in other topic notes) are evident in the discussion on whether EPC assessors should measure windows or not, and inconsistencies between SAP and RdSAP.

Within RdSAP, the measurement of individual windows is not required if the overall window area of the dwelling is assessed as 'typical', 'more than typical' or 'less than typical' (see Supplementary Topic Note 6 on Measuring Windows in RdSAP). Yet, RdSAP Appendix S does not define anywhere what is 'typical' other than provide the algorithms the programs use to calculate 'typical' window area for a given dwelling type, age, and floor area. The assessor is not helped in this process as none of the currently available approved RdSAP software programs[136] assists the assessor by displaying what the typical window area would be for a given dwelling type, age and total floor area. Effectively, the only way for an assessor to confirm whether a dwelling's window area is 'typical', 'more than typical' or 'less than typical', or not, is to actually measure all the window areas, aggregate the areas, calculate the typical window area from the appropriate Table S4 algorithm, and then compare the two areas manually. In other words, the assessor needs to measure the windows to confirm that the assessor does not need to measure them – Catch 22. The result is that some assessors never seem to measure windows, always classifying them as typical; others always measure windows regardless of whether they believe the glazing area is 'typical' or not.[137] This assessor discretion on whether to measure windows or not will give rise to some inconsistencies between assessors.

RdSAP 2012 introduced a divergence between SAP and RdSAP with regard to the default U-values associated with wood and uPVC-framed double glazing. In Table 6e of the SAP 2012 manual[138], wood and uPVC-framed double glazing have identical U-values as long as the glazing gap and other factors for the two types of double glazing are the same. RdSAP 2012 introduced variable U-values for pre-2003 uPVC-

[136] As far as the authors of this report are aware.
[137] These impressions come from canvassing assessors on whether they measure windows or not at various RdSAP masterclass events organised by Alembic Research and Energy Action Scotland over the years.
[138] https://www.bre.co.uk/filelibrary/SAP/2012/SAP-2012_9-92.pdf

framed double glazing based on the thickness of the glazing gap[139] while pre-2003 wood-framed double glazing only has one default regardless of the thickness of the glazing gap. Overwriting the wood framed double glazing U-value in RdSAP with a SAP Table 6e value is not allowed under RdSAP convention 3.10[140].

6.9.2 Measuring Windows

Issue:
To reduce inconsistencies between assessors, and between building assessments and actual energy performance, individual windows should be measured.

Analysis:
In RdSAP, the conventions require assessors to measure individual windows when there is more than 30% more than typical window area, or more than 30% less than typical window area. A study comparing the actual window measurements of 1398 Scottish dwellings with the areas predicted by the RdSAP algorithms found that these algorithms over-estimated the window area across most Scottish dwelling types when broken down by dwelling type and age band by more than 30%. In only three age band by house type groupings (1930-49 flats and maisonettes, 1950-64 flats and maisonettes, and 1984-91 flats and maisonettes) did RdSAP over-estimate the window area by less than 30%, and in two of these it was still more than 25% out (see Supplementary Topic Note 6 on Measuring Windows in RdSAP for the full results).

These results indicate that the default position for RdSAP assessors in Scotland should not be to assume that the window areas are typical and not measure; rather, they should assume that window areas are much less than typical compared to what the RdSAP window algorithms would predict, and measure the individual windows. Over-estimating window area has a direct consequence when it comes to assessing the benefits of wall insulation in RdSAP: the more window area subtracted from the total wall area, the less residual wall area to benefit from wall insulation. The impact of using actual window measurements, compared to the RdSAP defaults, is examined through a case study of 28 tenemental flats that received internal wall insulation in 2015/6 in Supplementary Topic Note 6 on Measuring Windows in RdSAP.

Requiring assessors to measure windows would increase the time in the dwelling, and increase the time entering the data into the software, and likely increase the cost of RdSAP assessments to householders (because an assessor would not be able to do as many per day). The results from doing so however would be in keeping with the actual dwelling, and would ensure greater consistency between assessors by

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[139] Pre-2003 uPVC-framed double glazing: 6mm gap = 3.1 W/m^{2}K; 12mm gap = 2.8 W/m^{2}K; 16mm or more gap = 2.6 W/m^{2}K. By contrast all pre-2003 wood-framed double glazing is defaulted to a U-value of 3.1 W/m^{2}K regardless of the gap (which is the equivalent of a 6mm gap, which in many instances is patently underestimating the thickness of the gap).
[140] RdSAP Conventions v10.0 for RdSAP 9.92 and 9.93 (applicable from December 31, 2017) https://www.bre.co.uk/filelibrary/SAP/2012/RdSAP-Conventions-10_0---from-31-December-2017.pdf

removing any discretion in deciding when to measure windows. As measuring individual windows would require data to be collected on the orientation and draughtiness of the individual windows this would allow the benefits of passive solar gains to be better modelled and air infiltration rates to be better assessed (see Section 6.7).

The alternative in Scotland to requiring assessors to measure individual windows would be to adjust the window algorithms to be more appropriate. This exercise would involve data collection and modelling work, and the subsequent re-writing of the algorithms within RdSAP. Requiring assessors to measure windows and enter the data into the program would require only a change in the convention. All the RdSAP software programs already have the function to input individual detailed window data, and would require no amendment to the software.

Possible Assessment action:
Change the convention to require RdSAP assessors to measure individual windows in all RdSAP assessments in Scotland.

- **Rationale: improve accuracy / improving consistency**
- **Time frame:** 🕐
- **Cost:** **£**
- **Impact:** **± ± ±**
- **Magnitude:** 🏠 🏠 🏠 🏠 🏠

6.9.3 Window U-values

Issue: Inconsistencies between SAP and RdSAP on uPVC and wood double glazed U-values.

Analysis: As already noted above in Section 5.8.4, RdSAP 2012 introduced a divergence between SAP and RdSAP with regard to the default U-values associated with wood and uPVC-framed double glazing, based on the thickness of the glazing gap. There does not appear to be an explanation why this variation was not also applied to similar glazing gaps with wood double glazing.

Possible Calculation action:
Include variations in pre-2003 wood double glazing default U-values to take account of different thicknesses in the glazing gap.

- **Rationale: improve accuracy**
- **Time frame:** 🕐🕐🕐
- **Cost:** **£ £ £**
- **Impact:** **±**
- **Magnitude:** 🏠 🏠 🏠

6.9.4 Secondary Glazing

Issue:
Secondary glazing is not included within the EPC recommendations.

Analysis:
The issue here is not that RdSAP does not recommend secondary glazing, but that such a recommendation is trumped within RdSAP by the recommendation to install replacement double glazing. Appendix T includes secondary glazing amongst the options to be assessed by RdSAP programs when assessing the improvement options for a dwelling. However, within the Appendix T hierarchy, replacement double glazing is also assessed and, as only one recommendation per building component replacement is made on the EPC; double glazing takes precedence over secondary glazing.

Within RdSAP, an assessor could remove replacement double glazing from the recommendations for a dwelling, with secondary double glazing then likely to be recommended in its place. The RdSAP conventions require an assessor to have documented reasons for removing a recommendation, and that being "a listed building or a property in a conservation area is not sufficient grounds in its own right to suppress a recommendation."[141]

Possible Calculation action:
Amend Appendix T so that both a recommendation for secondary glazing and replacement double glazing can appear on the EPC.

- **Rationale: improve reporting / recommendations**
- **Time frame:** 🕐🕐🕐
- **Cost:** **£ £ £**
- **Impact:** **±**
- **Magnitude:** 🏠 🏠 🏠

[141] See convention 8.01, RdSAP Conventions v10.0 for RdSAP 9.92 and 9.93 (applicable from December 31, 2017) https://www.bre.co.uk/filelibrary/SAP/2012/RdSAP-Conventions-10_0---from-31-December-2017.pdf

6.9.5 Shutters

Issue:
Shutters are not recommended in RdSAP.

Analysis:
In Section 6.2.11, assessing the impact of existing shutters was looked at in the context of traditional buildings. Currently, shutters are not included within an RdSAP assessment, and therefore are not part of the recommendations included in Appendix T. To get shutters included in the recommendations, shutters would need to be incorporated into the RdSAP methodology and software, and into Appendix T.

Possible Calculation action:
Incorporate shutters into the RdSAP methodology and into Appendix T.

- **Rationale: improve accuracy / improve reporting / recommendations**
- **Time frame:** 🕐🕐🕐
- **Cost:** **£ £ £**
- **Impact:** **±**
- **Magnitude:** 

7. Conclusions

Within the responses to the three public consultation documents that formed the basis of this report, satisfaction with the current system of assessing the energy performance of buildings in Scotland ranged from it being considered too subjective, flawed, inaccurate, inconsistent, not reflecting the true thermal performance of a building, and not fit for purpose, at one end of the spectrum; through to offering a simple, readily accepted, easy to understand, cost effective tool to underpin high level policy analysis to improve the energy performance of the dwelling stock at the other end. That there is truth in both extremes reflects the evolving purposes of the EPC system.

The current EPC process was designed to produce an asset rating to comply with the requirements of the EPBD. What may have been sufficient as a general measure of energy performance, using a simplified energy model and an A to G banding may not be appropriate if the same system is utilised to regulate compliance with energy efficiency standards in existing buildings.

To date the Scottish Government has aligned itself the rest of the UK on the calculation methodologies and assessment conventions, providing a consistent approach across all four nations. The Scottish Government has taken a different approach in some areas relating to EPCs and assessors, e.g. with regard to the establishment of protocol arrangements, the format of the domestic sector EPC, displaying EPCs in non-domestic buildings, and the creation of a Scottish register for lodging the EPCs, Action Plans and Display Energy Certificates. Going forward, it is within the remit of the Scottish Government to change or amend further any or all of the four components of the EPC process.

Taking ownership of the calculation methodologies and effectively establishing a Scottish SAP is likely to incur significant costs, efforts, and resources. However, the process of negotiating and agreeing desired changes with a number of other vested interests within the current arrangements may not address all of the issues of concern. Taking a more hands-on control of the shaping of assessor conventions, re-negotiating the existing protocol arrangements with regard to assessor training, and reformatting the EPC, could allow an increased Scottish dimension to be added to the EPC process without changing the underlying methodologies or calculations.

This review extracted 1066 contributions relating to SAP, RdSAP, SBEM and EPCs from the 343 published responses to the three consultation documents that were the source data for this report. These responses were collated, and grouped through a thematic analysis to identify topics and technical issues that were examined and discussed in more detail across 4 workshops that were organised in 4 different locations across Scotland in 2018. The 1066 contributions have been distilled down into 80 possible actions for the Scottish Government's consideration in taking forward the EPC process in Scotland. These possible actions are summarised and organised by whether they are related to calculation issues, assessment issues, reporting issues, or database issues in the final section of this report.

8. Possible Actions for EPCs in Scotland

In total, 80 recommendations were identified. They are presented below organised by whether they are related to calculation issues, assessment issues, reporting issues, or database issues. These areas have implications on who will take the action, and on the nature of the impact.

Calculation	Assessment	Reporting	Database

Domestic Building recommendations

Possible actions	rationale	time frame	cost	impact	magnitude
The Scottish Government to arrange for the data gathered through the monitoring of the SEEP Pathfinder projects and HEEPS ABS to be collated and assessed against improving the accuracy of the calculation methodologies.	improving accuracy	medium term	medium	low to medium	medium
A systematic research programme to measure in-situ U-values for different existing stone wall types to assess the validity of the current range of U-values within RdSAP; proposed revision to the stone wall U-value calculation algorithms. This research program would probably take at least 2 years to identify and monitor sufficient properties to provide a robust empirical basis to make changes to the existing algorithms. This research programme could assess the impact of the wall condition and water saturation levels on the thermal performance of the walls.	improving accuracy	long term	high cost	high	medium
Extending the range of stone wall types would require collating more empirical data in terms of the type of stone and its heat loss performance so that default U-values could be derived and included into the software. This certainly could be part of the above research program. In the interim, a piece of research could collate and calculate default U-values that could be published as a stand-alone booklet (or more likely as an online data reference) that could be referred to by assessors.	improving accuracy	medium term	low cost	medium	medium

Adopt thickness related U-values for half-brick thick, and for 1.5 and 2-brick thick walls, amend Appendix S accordingly, and then embed the appropriate defaults into the SAP, RdSAP and SBEM software models.	improving accuracy	medium term	medium to high cost	medium	low
Include an assessment of the dwelling's thermal mass into Appendix S of the SAP manual, and within the RdSAP software.	improving accuracy	medium term	medium	high	medium
Include shutters within RdSAP as an item to be recorded during the survey.	improving accuracy	medium term	low cost	low	low
Use The Guide to Non-traditional Housing in Scotland 1923 -1955[1], and other individual BRE reports on specific non-traditional dwelling types, to calculate theoretical U-values for different non-traditional dwelling types and incorporate them into SAP and RdSAP.	improving accuracy	long term	high cost	high	low
Establish a Scottish PCDB reference database to allow for Scottish-based inputs such as fuel costs and improvement costs, to calculate the EPC outputs on the EPC such as the savings on fuel costs, and the paybacks.	improving accuracy	long term	high cost	high	high
Amend RdSAP procedures and software to differentiate between CFLs and LED with regard to assessing lighting energy consumption, and potential savings.	improving accuracy	medium term	medium	low	medium to high
Allow the inclusion of in-situ test results such as air pressure testing or U-value measurements to be included into the RdSAP assessment of existing properties. Such procedures are already defined in SAP for dwellings.	improving accuracy	medium term	medium	high	high
The impact of the changing fuel prices on the SAP rating over time is accounted for in quite a blunt way within SAP and RdSAP. Rather than use an overall average fuel price index, a fuel price index for each fuel should be calculated and embedded with the SAP and RdSAP calculations. Going forward we can no longer have the confidence that all fuel costs will follow a similar trend or direction.	improving accuracy	long term	high cost	high	high
Review the financial benefit of embedded generation within the EPC process. Currently the SAP score on the EPC is improved with electricity generating renewables; however, it is not clear how this translates to an energy cost saving for the occupant.	improving accuracy	long term	high cost	high	low to medium

Develop a Scottish PCDB which all approved software would use when generating Scottish EPCs. This would have data on energy efficiency improvements and fuel prices which reflect the Scottish market.	improving accuracy	long term	high cost	high	high
Develop more algorithms for default room in the roof shapes	improving accuracy	long term	high cost	medium	medium
Redefine half-wall type dwellings in RdSAP.	improving accuracy	long term	high cost	medium	medium
Incorporate the full SAP DH/CHP system data entry items into the RdSAP methodology with appropriate conventions and defaults when the information is not available.	improving accuracy	medium to long term	high cost	high	low
Incorporate the full SAP DH/CHP system data entry items into the RdSAP methodology with appropriate conventions and defaults when the information is not available.	improving accuracy	medium to long term	high cost	high	low
Consider possible changes to the SAP and RdSAP methodology with regard to 'penalising' flat rate charging.	improving accuracy	medium term	medium	medium	low
Consider possible change to convention on definition of a heated corridor in multi-storey blocks connected to DH/CHP systems where the system risers are in the circulation areas.	improving accuracy	short term	low cost	low to medium	low
Allow the actual number of extract fans, air bricks, and flues, and the presence of a draught lobby to be entered within RdSAP programs.	improving accuracy	medium term	medium	medium	high
Allow for air infiltration rate test results to be entered into RdSAP.	improving accuracy	medium term	medium	medium	low to medium
Change the Appendix T rules so that draughtproofing is included as an improvement recommendation where the level of draughtproofing of the windows and doors is less than 100%.	improving reporting	medium term	medium	low	low
Include variations in pre-2003 wood double glazing default U-values to take account of different thicknesses in the glazing gap.	improving accuracy	medium term	medium	low	medium
Amend Appendix T so that both a recommendation for secondary glazing and replacement double glazing can appear on the EPC.	improving reporting	medium term	medium	low	medium
Incorporate shutters into the RdSAP methodology and into Appendix T.	improving accuracy and reporting	medium term	medium	low	low
Publish a convention to accommodate wall insulation that is less than 50mm thick, or falls between the default thicknesses.	improving accuracy	short term	low cost	low to medium	medium

'System built' conjures up negative perceptions, and the term should be switched to 'non-traditional'. System-built describes a particular method of construction; not all non-traditional housing in Scotland is system-built.	improving consistency	short term	low cost	low	low
Publish a guide on calculated and tested U-values for non-traditional and 'system built' buildings in Scotland	improving consistency	long term	high cost	high	low
Develop procedures and conventions to take account of insulation that cannot be seen. This would include adding an addendum to the data entry take account of insulation and improvements that do not meet the current standard of documentary evidence.	improving accuracy and consistency	medium term	medium	high	medium
Develop a household log book akin to the benchmark log book for boilers in which contractors would sign off insulation improvements completed in a dwelling.	improving accuracy and consistency	medium term	medium	high	medium
Clarify conventions with regard to using 'system built' as a wall type. This designation should only be used after all non-destructive means have been employed to categorise the wall type as this has a big influence on how measures are automatically generated for wall insulation.	improving consistency	long term	low cost	medium	low
Support the development of a wider role for EPC assessors in Scotland through further training, and CPD	improving consistency	medium to long term	medium to high cost	medium	high
Clarify RdSAP conventions with regard to circumstances under which automatic recommendations can be suppressed.	improving consistency	short term	low cost	low	low
Enable and allow assessors to modify the PCDB costs for improvement works, allowing the reporting of capital costs of improvement measures to be made more specific to the community where the works would be carried out.	improving consistency	medium to long term	medium to high cost	medium	high
Allow variations in the costs of the works proportionate with the percentage of the property being treated.	improving consistency	medium to long term	medium to high cost	low	low to medium
Amend the RdSAP software to allow for the inclusion of Appendix Q calculated savings for technologies not currently incorporated in RdSAP, following the same guidelines that are currently applied to using such procedures in SAP.	improving consistency	medium to long term	high cost	medium	low

Explore with SQA and RICS the development of a higher-qualified, broader-skilled, more professional EPC assessor.	improving consistency	long term	medium to high cost	medium	high
Undertake a research exercise to determine how many EPCs issued under RdSAP 2012 v9.92 breached the 'smart audit rules'.	improving consistency	short term	medium	high	high
Introduce 'smart auditing' as part of the Protocol Organisations' quality assurance targets in Scotland.	improving consistency	short term	low cost	high	high
Introduce the requirement that the quality assurance procedures include independent on-site re-inspections.	improving consistency	medium term	high cost	high	high
Establish an independent regulator (or vest it within Scottish Government) to oversee the independent re-inspection of EPC assessments, and to report annually on the results.	improving consistency	medium term	high cost	high	high
The Scottish Government in conjunction with SQA to identify and introduce Scottish qualifications, based on National Occupational Standards, for EPC assessors, for existing dwellings, new build dwellings, and non-domestic dwellings. Part of this qualification would be the potential assessor successfully completing a national examination.	improving consistency	medium term	high cost	high	high
All SAP, RdSAP and SBEM training courses being offered in Scotland, and the respective trainers, should be vetted with regard to their competence and the experience of the trainers. These items should not be left in the hands of the accreditation Schemes.	improving consistency	medium term	medium	high	high
The Scottish Government to agree with the Accreditation Schemes rules and procedures for suspending and de-registering assessors or companies that bring the EPC scheme into disrepute by misrepresenting data.	improving consistency	medium term	medium	high	high
The convention on rooms in the roof should be re-written to provide clear, unambiguous and definitive guidance on when detailed room in the roof measurements are required.	improving consistency	medium term	medium	medium	low
Develop procedures to take account of insulation that cannot be seen. This would include adding an addendum to the data entry that the U-values take account of insulation that has not been accompanied by the current standard of documentary	improving consistency	medium term	medium	medium	low

evidence.					
Develop a household log book akin to the benchmark log book for boilers in which contractors would sign off insulation improvements completed in a dwelling.	improving consistency	medium term	medium	high	high
Require a full SAP assessment when a dwelling is connected to a DH/CHP system.	improving accuracy	medium to long term	high cost	high	low
Define a convention on when to make the recommendation to connect to a local DH/CHP system.	improving consistency	short term	low cost	high	low
The Scottish Government could mandate that Display Energy Certificate-type certificates be displayed outside the door on boiler plant setting out the DH/CHP operational efficiencies. This would provide an accessible source of data to the assessor.	improving accuracy	medium term	low cost	high	low
The Scottish Government should encourage DH/CHP system owners to get the operational parameters of their systems added to the PCDB database.	improving accuracy	medium term	low cost	high	low
Define a convention in RdSAP for assessing air bricks.	improving consistency	medium term	medium	low	high
To support the inclusion of air infiltration rate test results, define a convention within RdSAP governing the necessary standards to be met by the tests, the qualifications of those carrying out the tests, and the requisite documentation to support this development.	improving accuracy and consistency	medium term	medium	medium	medium
Change the convention to require RdSAP assessors to measure individual windows in Scotland.	improving accuracy and consistency	short term	low cost	medium	high
Identify appropriate wall insulation techniques for different non-traditional dwelling types so that the EPC will potentially recommend insulating the walls.	improving reporting	medium term	medium	high	low
Incorporate shutters into Appendix T so that they may appear as a possible improvement.	improving reporting	medium term	medium	low	low
In order to avoid significant material changes to the EPC as required for EPBD, consideration should be given to a separate associated energy efficiency advice report or improvements report. This report	improving reporting	long term	high cost	high	high

would be both methodologically and administratively linked to the EPC itself.					
The format of the EPC in Scotland should reflect on the potential for assistance through Scottish Government schemes and/or the Energy Companies Obligation. Assessors are currently required to identify the tenure of the properties being assessed and many of the schemes for assistance are targeted at specific tenures. Messages around whether the property does or does not meet a sectoral EPC band target could be provided on the EPC.	improving reporting	long term	high cost	high	high
In order to avoid significant material changes to the EPC as required for EPBD, consideration should be given to a separate associated energy efficiency advice report or improvements report. This report would be both methodologically and administratively linked to the EPC itself.	improving reporting	long term	high cost	high	high
Use the EPC data to provide tailored advice and support to householders by developing a parallel reporting process.	improving reporting	long term	high cost	high	high
A consumer review of the EPC format is needed in order to revise the way that information is presented on the document so that it is understandable by the householder, and not just a technical audience. The review should consider information such the values and terms used and what these mean to the consumer. The certificate itself is an authorised legal document; however, the information contained within certain sections is indicative and not an approved schedule of planned works.	improving reporting	long term	high cost	high	high
Amend the wording on the EPC with regard to recommendations for specific construction types, that more additional expertise is needed. This could be done achieved through the assessor selecting an addendum item for the need for professional expertise with specific construction types.	improving reporting	long term	high cost	high	high
Amend the wording on the EPC with regard to recommendations where the building is obviously not wind and weather tight that additional work may be required for the benefits of any improvement works	improving reporting	long term	high cost	high	high

are to be realised. This could be done achieved through the assessor selecting an addendum item for the need for professional expertise with specific construction types.					
Develop differential SAP targets for dwellings for different primary heating fuels.	improving reporting	long term	high cost	high	high
Where the rating is subject to the type of metering (e.g. with electric storage heating) or the presence of low energy lighting, a note should be added to the EPC stating that switching tariffs or replacing the low energy lighting with less efficient lighting may have a negative impact on the rating.to landlords and owners on the actions that can have an adverse impact on the SAP rating.	improving reporting	short to medium	low cost	low to medium	low to medium
Adjust the presentation of fuel costs and savings to reflect annual fuel bills (not 3-year totals) and annual savings. There may also be some benefit of also including what the annual total converts to in terms of an average weekly fuel bill in summer and winter, to better inform householders.	improving reporting	medium term	medium	low	high
Consider the value that can be added to the EPC process with a separate occupant report. This kind of approach could help to address the view that the EPC in itself should not fundamentally change; the data used to generate it could add significant value to a supplementary advice report which then brings into play specific occupant factors.	improving reporting	long term	high cost	high	high
Adjust the wording on the domestic EPC so that it refers to carbon dioxide equivalent (or CO2e) emissions rather than simply carbon dioxide.	improving reporting	short term	low cost	low	high
All data referenced from the PCDB to produce the various metrics on an EPC should be declared on the lodged document.	improving reporting	long term	medium	low	high
Use the EPC data to provide tailored advice and support to householders by developing a parallel reporting process.	improving reporting	long term	high cost	high	high
Include connecting to DH/CHP system within Appendix T.	improving reporting	medium term	medium	high	low
Require the summary data report to be lodged on the national register alongside the EPC, and to make this summary report available online	improving reporting	medium term	high cost	medium	high

alongside the EPC.					
Develop a database alongside the EPC register to upload PAS2030 certificates of compliance that can be accessed by householders and assessors to check if insulation has been installed.	improving consistency	medium term	high cost	medium	medium

Non-domestic Building recommendations

Possible actions	rationale	time frame	cost	impact	magnitude
Contact BRE/UK Government department to determine whether there are any plans to increase the range of new technologies catered for in SBEM.	improving accuracy	medium term	medium	high	medium
Amend the EPC generator module to allow input of operational energy data such as used in DECs in other parts of the UK.	improving accuracy	medium term	medium	medium	medium
Require more detailed energy audits as the basis for funding decisions.	improving accuracy	short term	low cost	low to medium	medium
Include operational ratings on EPCs in addition to asset rating. Include more comparators (e.g. typical figures for building stock, or at least the building archetype).	improving reporting and recommendations	medium term	medium	low to medium	high
Publish operational as well as asset information on EPCs.	improving reporting and recommendations	medium term	low to medium cost	low to medium	medium
EPCs should not be used as the basis for works specifications or costs without further more detailed assessment.	improving reporting and recommendations	short term	low cost	medium	medium
Produce and publish a database of EPCs and operational energy consumption for public buildings in Scotland	improving accuracy	medium term	medium	low to medium	high

Appendix A.1: Word search terms, phrases and acronyms used to identify contributions to be extracted from responses to three public consultations

EPC	SAP	SBEM
NCM	non-domestic	model
survey	assess / assessment	rating
energy performance	certificate	label
calculate / calculation	data / database	qualify / qualification
recommendation	audit	

Appendix A.2: Metatags and Broad themes and descriptors applied to contributions extracted from responses to three public consultations

Metatags

- **Issue Classification**: calculation / assessment / reporting / database / none
- **Sector**: domestic / non-domestic / both / none
- **EPC comment**: critical / positive / neutral / none

Broad themes: descriptors

- **Methodology**: administration / Appendix T / alternative / defaults / mapping / metric / new technologies / PCDB / real data / scale / thermal mass / none
- **Modelling**: accuracy / consistency / defaults / metric / minimum standards / real data / standard occupancy / thermal mass / U-values / validation / none
- **Occupancy**: actual / standard occupancy / none
- **Convention**: consistency / none
- **Location**: Australia / city centre / Denmark / off gas / rural / Scotland / none
- **Built Form**: hard to treat / masonry / non-traditional / older / pre-1919 / pre-1940 / room in roof / Scottish housing stock / size / traditional / whole building / none
- **Condition**: condition / tolerable standard / none
- **Age of dwelling**: age / post-war / pre-1919 / none
- **Heating**: district / electric / heat pumps / infra-red heating / low carbon / micro-cogeneration / portable / sizing / thermal storage / wood / none
- **Energy supply**: fuel switching / renewables / tariffs / none
- **Fabric**: brick / glazing / insulation / loft insulation / shutters / solid walls / stone walls / thermal mass / wall insulation / windows / none
- **Ventilation**: draught lobbies / infiltrations / ventrolla / draughtproofing / none
- **Improvements**: appropriateness / costs / customised / minimum standards / recommendations / none
- **Report**: appropriateness / assumptions / benchmarking / costs / customised / minimum standards / total energy / none
- **Assessor**: competence / integrity / independence / quality assurance / none
- **Data storage and retrieval**: database / register / none
- **Data collection**: amend / big data / improvements / real data / smart meters / thermal imaging / none
- **Climate**: local / standard / none

Appendix A.3: Keywords used to categorise the nature of individual contributions extracted from responses to three public consultations

Administration	Affordable warmth	Alternative model
Awareness of SAP / RdSAP	Benchmarking	Conventions
Database	Decarbonisation	District heating
Electric heating	Embodied energy	Flawed
Fuel poverty	Hard to treat	Metric
Minimum standards	New technologies	Performance gap
Quality assurance	Real data	Recommendations
Reporting	Review and update	Rooms in roof
Surveyor skills	Thermal imaging	Thermal mass
Traditional buildings	Ventilation	Windows

Appendix A.4: Pivot Table Analysis: Broad theme by source document by issue classification by sector

MODELLING	Count
LHEES	
assessment	
both	9
domestic	4
non-dom	1
assessment Total	**14**
calculation	
both	10
domestic	3
non-dom	5
calculation Total	**18**
database	
both	3
domestic	8
database Total	**11**
LHEES Total	**43**
PRS	
assessment	
both	41
domestic	61
assessment Total	**102**
calculation	
both	104
domestic	81
calculation Total	**185**
database	
both	1
database Total	**1**
reporting	
both	101
domestic	117
non-dom	3
reporting Total	**221**
PRS Total	**509**
SEEP	
assessment	
both	22
domestic	5
non-dom	4
assessment Total	**31**
calculation	
both	74
domestic	24
non-dom	8
calculation Total	**106**
reporting	
both	25
domestic	6
non-dom	2
reporting Total	**33**
SEEP Total	**170**
Grand Total	**722**

METHODOLOGY	Count
LHEES	
assessment	
both	10
domestic	4
non-dom	1
assessment Total	**15**
calculation	
both	11
domestic	3
non-dom	5
calculation Total	**19**
database	
both	3
domestic	9
database Total	**12**
reporting	
both	2
reporting Total	**2**
LHEES Total	**48**
PRS	
assessment	
both	46
domestic	65
assessment Total	**111**
calculation	
both	104
domestic	82
calculation Total	**186**
database	
both	2
database Total	**2**
reporting	
both	107
domestic	144
non-dom	4
reporting Total	**255**
PRS Total	**554**
SEEP	
assessment	
both	22
domestic	7
non-dom	5
assessment Total	**34**
calculation	
both	76
domestic	25
non-dom	7
calculation Total	**108**
reporting	
both	31
domestic	12
non-dom	6
reporting Total	**49**
SEEP Total	**191**
Grand Total	**793**

OCCUPANCY	
	Count
LHEES	
assessment	
both	4
domestic	4
assessment Total	**8**
calculation	
both	3
domestic	1
calculation Total	**4**
database	
both	3
domestic	5
database Total	**8**
LHEES Total	**20**
PRS	
assessment	
both	3
domestic	4
assessment Total	**7**
calculation	
both	18
domestic	11
calculation Total	**29**
reporting	
both	7
domestic	14
non-dom	1
reporting Total	**22**
PRS Total	**58**
SEEP	
assessment	
both	4
domestic	2
assessment Total	**6**
calculation	
both	22
domestic	9
non-dom	1
calculation Total	**32**
reporting	
both	8
domestic	4
reporting Total	**12**
SEEP Total	**50**
Grand Total	**128**

CONVENTION	
	Count
PRS	
assessment	
both	16
domestic	20
assessment Total	**36**
calculation	
both	9
domestic	7
calculation Total	**16**
reporting	
both	8
domestic	6
reporting Total	**14**
PRS Total	**66**
SEEP	
assessment	
both	4
assessment Total	**4**
calculation	
both	1
domestic	1
calculation Total	**2**
reporting	
both	3
reporting Total	**3**
SEEP Total	**9**
Grand Total	**75**

reporting	
both	1
domestic	1
non-dom	3
reporting Total	**5**
SEEP Total	**12**
Grand Total	**65**

LOCATION	Count
LHEES	
database	
domestic	1
database Total	**1**
LHEES Total	**1**
PRS	
assessment	
both	6
domestic	11
assessment Total	**17**
calculation	
both	6
domestic	13
calculation Total	**19**
reporting	
both	5
domestic	11
reporting Total	**16**
PRS Total	**52**
SEEP	
calculation	
both	3
domestic	4
calculation Total	**7**
reporting	
both	1
domestic	1
non-dom	3
reporting Total	**5**
SEEP Total	**12**
Grand Total	**65**

BUILT FORM	Count
PRS	
assessment	
both	18
domestic	23
assessment Total	**41**
calculation	
both	13
domestic	17
calculation Total	**30**
reporting	
both	8
domestic	14
reporting Total	**22**
PRS Total	**93**
SEEP	
assessment	
both	2
domestic	3
assessment Total	**5**
calculation	
domestic	3
non-dom	1
calculation Total	**4**
reporting	
non-dom	1
reporting Total	**1**
SEEP Total	**10**
Grand Total	**103**

CONDITION	Count
LHEES	
assessment	
both	1
assessment Total	**1**
LHEES Total	**1**
PRS	
assessment	
both	8
domestic	5
assessment Total	**13**
calculation	
both	1
calculation Total	**1**
PRS Total	**14**
SEEP	
assessment	
both	3
domestic	1
assessment Total	**4**
SEEP Total	**4**
Grand Total	**19**

AGE OF DWELLING	
	Count
PRS	
assessment	
both	1
domestic	3
assessment Total	**4**
calculation	
domestic	2
calculation Total	**2**
reporting	
domestic	2
reporting Total	**2**
PRS Total	**8**
SEEP	
assessment	
both	2
domestic	1
assessment Total	**3**
calculation	
non-dom	1
calculation Total	**1**
SEEP Total	**4**
Grand Total	**12**

ENERGY SUPPLY	
	Count
PRS	
assessment	
domestic	2
assessment Total	**2**
calculation	
both	5
domestic	5
calculation Total	**10**
reporting	
both	1
domestic	2
reporting Total	**3**
PRS Total	**15**
SEEP	
assessment	
domestic	1
assessment Total	**1**
calculation	
both	8
domestic	5
calculation Total	**13**
SEEP Total	**14**
Grand Total	**29**

HEATING	
	Count
LHEES	
assessment	
both	5
assessment Total	**5**
calculation	
both	2
calculation Total	**2**
database	
domestic	2
database Total	**2**
LHEES Total	**9**
PRS	
assessment	
both	2
domestic	3
assessment Total	**5**
calculation	
both	12
domestic	11
calculation Total	**23**
reporting	
both	1
domestic	3
reporting Total	**4**
PRS Total	**32**
SEEP	
assessment	
both	1
assessment Total	**1**
calculation	
both	14
domestic	3
calculation Total	**17**
reporting	
both	3
domestic	2
reporting Total	**5**
SEEP Total	**23**
Grand Total	**64**

FABRIC	
	Count
PRS	
assessment	
both	8
domestic	13
assessment Total	**21**
calculation	
both	8
domestic	9
calculation Total	**17**
reporting	
both	1
domestic	8
reporting Total	**9**
PRS Total	**47**
SEEP	
assessment	
both	2
domestic	2
assessment Total	**4**
calculation	
both	2
domestic	2
non-dom	1
calculation Total	**5**
SEEP Total	**9**
Grand Total	**56**

VENTILATION	
	Count
LHEES	
assessment	
domestic	1
assessment Total	**1**
calculation	
domestic	1
calculation Total	**1**
LHEES Total	**2**
PRS	
assessment	
both	2
domestic	4
assessment Total	**6**
calculation	
both	1
domestic	1
calculation Total	**2**
PRS Total	**8**
SEEP	
assessment	
both	1
assessment Total	**1**
SEEP Total	**1**
Grand Total	**11**

IMPROVEMENTS	
	Count
LHEES	
assessment	
both	2
domestic	2
assessment Total	**4**
reporting	
both	1
reporting Total	**1**
LHEES Total	**5**
PRS	
assessment	
both	26
domestic	32
assessment Total	**58**
calculation	
both	16
domestic	13
calculation Total	**29**
reporting	
both	57
domestic	102
non-dom	1
reporting Total	**160**
PRS Total	**247**
SEEP	
assessment	
both	10
domestic	3
assessment Total	**13**
calculation	
both	7
domestic	1
calculation Total	**8**
reporting	
both	11
domestic	5
reporting Total	**16**
SEEP Total	**37**
Grand Total	**289**

REPORT	Count
LHEES	
assessment	
both	1
domestic	2
assessment Total	**3**
LHEES Total	**3**
PRS	
assessment	
both	26
domestic	32
assessment Total	**58**
calculation	
both	16
domestic	12
calculation Total	**28**
reporting	
both	58
domestic	105
non-dom	1
reporting Total	**164**
PRS Total	**250**
SEEP	
assessment	
both	10
domestic	3
non-dom	2
assessment Total	**15**
calculation	
both	8
domestic	2
non-dom	1
calculation Total	**11**
reporting	
both	11
domestic	7
non-dom	2
reporting Total	**20**
SEEP Total	**46**
Grand Total	**299**

ASSESSOR	Count
LHEES	
assessment	
domestic	2
non-dom	1
assessment Total	**3**
LHEES Total	**3**
PRS	
assessment	
both	70
domestic	173
assessment Total	**243**
calculation	
both	2
calculation Total	**2**
reporting	
both	3
domestic	7
reporting Total	**10**
PRS Total	**255**
SEEP	
assessment	
both	21
domestic	3
assessment Total	**24**
calculation	
both	2
domestic	1
calculation Total	**3**
reporting	
both	4
domestic	1
reporting Total	**5**
SEEP Total	**32**
Grand Total	**290**

DATA STORAGE & RETRIEVAL	
	Count
LHEES	
assessment	
domestic	2
assessment Total	**2**
calculation	
both	1
non-dom	3
calculation Total	**4**
database	
both	4
domestic	7
database Total	**11**
LHEES Total	**17**
PRS	
calculation	
both	1
calculation Total	**1**
database	
both	4
domestic	3
database Total	**7**
reporting	
both	1
domestic	3
reporting Total	**4**
PRS Total	**12**
SEEP	
database	
both	3
domestic	1
database Total	**4**
SEEP Total	**4**
Grand Total	**33**

DATA COLLECTION	
	Count
LHEES	
assessment	
both	1
domestic	2
non-dom	1
assessment Total	**4**
calculation	
both	5
domestic	1
non-dom	3
calculation Total	**9**
database	
both	4
domestic	7
database Total	**11**
LHEES Total	**24**
PRS	
calculation	
both	2
calculation Total	**2**
database	
both	4
domestic	2
database Total	**6**
reporting	
both	1
domestic	3
reporting Total	**4**
PRS Total	**12**
SEEP	
assessment	
both	3
non-dom	1
assessment Total	**4**
calculation	
both	5
domestic	1
non-dom	1
calculation Total	**7**
database	
both	3
database Total	**3**
reporting	
both	1
non-dom	1
reporting Total	**2**
SEEP Total	**16**
Grand Total	**52**

Climate	
	Count
LHEES	
assessment	
both	1
assessment Total	**1**
calculation	
both	2
calculation Total	**2**
database	
both	2
domestic	1
database Total	**3**
LHEES Total	**6**
PRS	
assessment	
both	1
assessment Total	**1**
calculation	
both	8
domestic	3
calculation Total	**11**
reporting	
both	2
reporting Total	**2**
PRS Total	**14**
SEEP	
calculation	
both	4
domestic	1
non-dom	1
calculation Total	**6**
SEEP Total	**6**
Grand Total	**26**

Appendix A.5: Frequency of Keyword by Source Document and Sector

Source document	Count
LHEES	
both	
database	2
decarbonisation	1
district heating	8
electric heating	1
metric	1
performance gap	3
real data	8
recommendations	2
reporting	1
thermal imaging	1
both Total	**28**
domestic	
database	8
decarbonisation	1
district heating	2
performance gap	1
real data	1
recommendations	2
ventilation	1
domestic Total	**16**
non-dom	
alternative model	2
real data	4
surveyor skills	1
non-dom Total	**7**
LHEES Total	**51**

Source document	Count
PRS	
both	
administration	3
alternative model	4
awareness of SAP	12
benchmarking	1
database	4
decarbonisation	9
district heating	1
electric heating	4
flawed	13
hard to treat	1
metric	35
minimum standards	6
new technologies	13
performance gap	31
quality assurance	48
real data	2
recommendations	78
reporting	2
review and update	10
room in roof	1
surveyor skills	21
thermal imaging	1
traditional buildings	19
ventilation	2
both Total	**321**
domestic	
administration	1
affordable warmth	1
alternative model	8
awareness of SAP	16
conventions	18
database	5
decarbonisation	3
district heating	5
electric heating	5
flawed	2
fuel poverty	4
hard to treat	1
metric	21
minimum standards	47
new technologies	5
performance gap	36
quality assurance	16
recommendations	88
reporting	3
review and update	4
surveyor skills	155
thermal mass	3
traditional buildings	10
ventilation	5
windows	2
domestic Total	**464**
non-dom	
benchmarking	2
performance gap	1
recommendations	1
non-dom Total	**4**
PRS Total	**789**

Source document	Count
SEEP	
both	
affordable warmth	1
awareness of SAP	8
benchmarking	8
database	2
decarbonisation	13
district heating	3
electric heating	1
embodied energy	2
flawed	2
fuel poverty	1
metric	8
minimum standards	2
new technologies	5
performance gap	55
quality assurance	17
real data	2
recommendations	13
review and update	2
surveyor skills	5
thermal imaging	2
thermal mass	2
traditional buildings	2
both Total	**156**
domestic	
affordable warmth	2
alternative model	1
awareness of SAP	6
conventions	1
database	1
decarbonisation	5
fuel poverty	1
hard to treat	1
metric	5
new technologies	2
performance gap	10
quality assurance	6
real data	1
recommendations	3
reporting	3
traditional buildings	2
domestic Total	**50**
non-dom	
benchmarking	12
new technologies	1
performance gap	3
real data	1
recommendations	2
review and update	1
non-dom Total	**20**
SEEP Total	**226**
3 Consultations Total contributions	**1066**

Appendix A.6 PCDB data for a range of energy efficiency measures

Energy Efficiency Measure	Column3	Variable Cost	Bottom (A)	Bottom (B)	Top (A)	Top (B)	GD Lifetime	GD Cost (£)	Green Deal	IUF (SAP)	IUF (OA)	Min SAP inc	Last Updated
Loft Insulation	Range		100		350		42		Yes	1	0.65	0.95	25/01/2012 09:42
Flat Roof Insulation	Range		850		1500		20		Yes	1	0.85	0.95	25/01/2012 09:42
Roof Room Insulation	Range		1500		2700		42		Yes	1	0.75	0.95	06/03/2012 16:19
Cavity Wall Insulation	Range		500		1500		42	500	Yes	1	0.9	0.95	13/11/2017 17:01
Party Wall Insulation	Range		300		600		42		Yes	1	0.85	0.95	17/12/2013 14:30
Hot Water Cylinder Insulation	Range		15		30		10		Yes	1	0.85	0.45	06/03/2012 16:19
Draughtproofing	Range		80		120		10		Yes	1	0.85	0.45	25/01/2012 09:42
Low Energy Lights	Single	Fixed Lights	0	5			5		No	1	1	0.45	25/01/2012 09:42
Cylinder Thermostat	Range		200		400		12		Yes	1	0.9	0.95	25/01/2012 09:42
Heating Controls for Wet CH	Range		350		450		12		Yes	1	0.5	0.95	25/01/2012 09:42
Heating Controls for Warm Air	Range		350		450		12		Yes	1	0.5	0.95	25/01/2012 09:42
Upgrade Boiler (same fuel)	Range		2200		3000		12		Yes	1	0.75	0.95	25/01/2012 09:42
Biomass Boiler	Range		7000		13000		20		Yes	1	0.75	0.95	04/05/2012 07:59
New or Replacement Storage Heaters	Range	Hab Rooms	0	400	0	600	20		Yes	1	0.9	0.95	17/12/2013 14:30
Replacement Warm Air Unit	Range		1250		2500		20		Yes	1	0.75	0.95	17/12/2013 14:30
Solar Water Heating	Range		4000		6000		25		Yes	1	1	0.95	25/01/2012 09:42
Double Glazed Windows	Range		3300		6500		20		Yes	1	0.85	0.95	25/01/2012 09:42
Glazing Replacement	Range		1000		1400		20		Yes	1	0.85	0.95	17/12/2013 14:30
Secondary Glazing	Range		1000		1500		20		Yes	1	0.85	0.95	25/01/2012 09:42
Solid Wall Insulation	Range		4000		14000		36		Yes	1	0.85	0.95	13/11/2017 17:01
EWI with CWI	Range		4500		15500		36		Yes	1	0.7	0.95	06/03/2012 16:19
Condensing Oil Boiler	Range		3000		7000		12		Yes	1	0.75	0.95	25/01/2012 09:42
Condensing Gas Boiler (no fuel switch)	Range		3000		7000		12		Yes	1	0.75	0.95	25/01/2012 09:42
Condensing Gas Boiler (fuel switch)	Range		3000		7000		12		Yes	1	0.75	0.95	25/01/2012 09:42
Flue Gas Heat Recovery	Range		400		900		12		Yes	1	0.9	0.95	15/08/2014 15:40
Photovoltaics	Range		5000		8000		25		Yes	1	1	0.95	15/08/2014 15:40
Wind Turbine	Range		15000		25000		10		Yes	1	1	0.95	05/04/2012 10:27
Floor Insulation (suspended floor)	Range		800		1200		42		Yes	1	0.85	0.95	25/01/2012 09:42
Floor Insulation (solid ground floor)	Range		4000		6000		42		Yes	1	0.85	0.95	22/01/2014 12:10
Insulated Doors	Single	No. Ext Doors	0	500			30		Yes	1	0.85	0.95	25/01/2012 09:42
Waste Water Heat Recovery	Range		585		725		20		Yes	1	0.9	0.95	20/02/2012 09:10
ASHP or GSHP (radiator distribution)	Range		3000		10000		15		Yes	1	0.75	0.95	15/08/2014 15:40
ASHP or GSHP (unerfloor distribution)	Range		3000		10000		15		Yes	1	0.75	0.95	15/08/2014 15:40
Micro-CHP	Single		5500				15		Yes	1	0.75	0.95	12/06/2012 09:56

Appendix A.7: Historic fuel prices used by SAP/RdSAP for calculation of fuel costs

	From January 2018		From July 2017		From January 2017		From July 2016		From January 2016		From July 2015	
Fuel	**Standing charge £/year**	**Unit price p/kWh**	**Standing charge £/year**	**Unit price p/kWh**	**Standing charge £/year**	**Unit price p/kWh**	**Standing charge £/year**	**Unit price p/kWh**	**Standing charge £/year**	**Unit price p/kWh**	**Standing charge £/year**	**Unit price p/kWh**
mains gas	**87**	**4.01**	89	4.1	90	4.2	92	4.28	95	4.32	101	4.25
bulk LPG	**70**	**6.53**	70	6.67	70	6.86	70	7.62	70	8.15	70	8.46
bottled LPG		**10.45**		10.54		10.62		10.24		10.44		10.61
heating oil		**3.66**		3.89		4.13		4.53		5.06		5.43
house coal		**4.14**		4.13		4.14		4.10		4.07		4.01
anthracite		**4.22**		4.22		4.21		4.15		4.09		4.02
manufactured smokeless fuel		**5.22**		5.19		5.18		5.14		5.09		5.04
wood logs		**4.65**		4.65		4.65		4.65		4.65		4.65
wood pellets secondary		**6.08**		6.09		6.09		6.18		6.02		6.30
wood pellets main heating		**5.5**		5.51		5.52		5.59		5.67		5.70
wood chips		**3.47**		3.46		3.47		3.43		3.41		3.36
dual fuel appliance		**4.51**		4.5		4.5		4.46		4.42		4.36
standard tariff	**70**	**16.12**	67	15.7	67	15.54	68	15.44	67	15.32	66	15.06
7-hour tariff high rate	**8**	**18.97**	8	18.47	8	18.32	8	18.25	10	18.15	13	17.81
7-hour tariff low rate		**7.06**		7.02		6.98		6.92		6.86		6.67
10-hour tariff high rate	**7**	**18.22**	7	17.23	7	17.23	8	17.17	9	17.43	11	17.10
10-hour tariff low rate		**10.06**		9.88		9.88		9.73		9.58		9.28
18-hour tariff high rate	**11**	**14.72**	11	14.44	11	14.44	11	14.32	12	14.2	12	14.08
18-hour tariff low rate		**10.01**		9.83		9.83		9.62		9.41		9.08
24-hour heating tariff	**31**	**9.64**	31	9.36	32	9.36	37	9.20	43	9.04	51	8.76
electricity sold to grid		**16.12**		15.7		15.54		15.44		15.32		15.06
community	**87**	**4.89**	89	5	92	5.12	92	5.22	95	5.27	101	5.18
community CHP		**3.42**		3.5		3.58		3.65		3.69		3.63

A.7 Historic fuel prices used by SAP/RdSAP for calculation of fuel costs (cont.)

	From January 2015		From July 2014		From January 2014		From July 2013		From January 2013	
Fuel	**Standing charge £/year**	**Unit price p/kWh**	**Standing charge £/year**	**Unit price p/kWh**	**Standing charge £/year**	**Unit price p/kWh**	**Standing charge £/year**	**Unit price p/kWh**	**Standing charge £/year**	**Unit price p/kWh**
mains gas	109	4.18	113	4.04	116	3.84	119	3.64	120	3.48
bulk LPG	70	8.44	70	8.40	70	8.27	70	8.04	70	7.60
bottled LPG		10.76		10.90		10.89		10.59		10.30
heating oil		5.75		5.87		5.95		5.74		5.44
house coal		3.95		3.88		3.78		3.71		3.67
anthracite		3.98		3.91		3.85		3.76		3.67
manufactured smokeless fuel		4.97		4.90		4.78		4.69		4.61
wood logs		4.65		4.65		4.65		4.60		4.23
wood pellets secondary		6.11		6.16		6.02		5.88		5.81
wood pellets main heating		5.53		5.57		5.45		5.32		5.26
wood chips		3.31		3.25		3.17		3.11		3.07
dual fuel appliance		4.30		4.22		4.11		4.03		3.98
standard tariff	64	14.81		14.47		14.02		13.59		13.19
7-hour tariff high rate	13	17.48	16	17.06	20	16.46	23	15.85	25	15.29
7-hour tariff low rate		6.49		6.26		6.00		5.74		5.50
10-hour tariff high rate	12	16.79	16	16.38	19	15.81	22	15.22	23	14.68
10-hour tariff low rate		8.85		8.54		8.18		7.83		7.50
18-hour tariff high rate	55	13.97								
18-hour tariff low rate		8.74								
24-hour heating tariff	78	7.55	77	7.35	74	7.05	72	6.84	70	6.61
electricity sold to grid		14.81		14.47		14.02		13.59		13.19
community	109	5.10	113	4.93	116	4.68	119	4.44	120	4.24
community CHP		3.57		3.45		3.28		3.11		2.97

Appendix A.8: Additional tables on consultation responses by topics and themes

Traditional buildings

Categorisation of Consultation Responses on Traditional Buildings

	Total Number of responses	Number of critical responses	source of critical response: LHEES consultation	source of critical response: SEEP consultation	source of critical response: PRS consultation
Calculation issues	27	22	0	2	20
Assessment issues	27	6	0	0	6
Reporting issues	32	4	0	0	4
Database issues	0	0	0	0	0
Total responses	86	32	0	2	30

Categorisation of Consultation 'Non-critical' Responses on Traditional Buildings

	Number of neutral responses	source of neutral response: LHEES consultation	source of neutral response: SEEP consultation	source of neutral response: PRS consultation
Calculation issues	5	0	0	5
Assessment issues	21	0	3	18
Reporting issues	28	0	1	27
Database issues	0	0	0	0
Total responses	54	0	4	50

Reporting and Recommendations

Recommendations: Appendix T method

Response Term [A.3]	Assessment		Total	Calculation		Total	Reporting				Total	Grand Total
	critical	*neutral*		*critical*	*neutral*		*critical*	*neutral*	*none*	*positive*		
decarbonisation				1		1			1		1	**2**
district heating					2	2		4			4	**6**
minimum standards		7	7				1	31		1	33	**40**
new technologies		1	1					1			1	**2**
quality assurance		1	1		1	1						**2**
recommendations	3	24	27	2	5	7	5	55	1	1	62	**96**
surveyor skills		1	1									**1**
traditional buildings	1	2	3									**3**
Grand Total	**4**	**36**	**40**	**3**	**8**	**11**	**6**	**91**	**2**	**2**	**101**	**152**

Reference values and costs contained in the Product Characteristics Database (PCDB)

Response Term [A.3]	Assessment		Total	Calculation		Total	Reporting		Total	Grand Total
	critical	*neutral*		*critical*	*neutral*		*critical*	*neutral*		
metric								1	1	**1**
performance gap								3	3	**3**
recommendations	1	2	3	2	5	7	2	33	35	**45**
surveyor skills								1	1	**1**
Grand Total	**1**	**2**	**3**	**2**	**5**	**7**	**2**	**38**	**40**	**50**

Meeting minimum standards

Response Term [A.3]	Assessment	Total	Calculation	Total	Reporting		Total	Grand Total
	neutral		*neutral*		*critical*	*neutral*		
electric heating	1	1						**1**
minimum standards	8	8	1	1	2	30	32	**41**
recommendations	1	1				7	7	**8**
Grand Total	**10**	**10**	**1**	**1**	**2**	**37**	**39**	**50**

Recognising new technologies

Response Term [A.3]	Assessment	Total	Calculation		Total	Reporting	Total	Grand Total
	neutral		*critical*	*neutral*		*neutral*		
new technologies			2	1	3	2	2	5
recommendations	1	1				2	2	3
review and update				1	1			1
Grand Total	1	1	2	2	4	4	4	9

RdSAP methodology: Metric

Response Term [A.3]	Assessment			Total	Calculation		Total	Reporting			Total	Grand Total
	critical	*neutral*	*positive*		*critical*	*neutral*		*critical*	*neutral*	*positive*		
decarbonisation									2		2	**2**
electric heating		1		1								**1**
flawed								1			1	**1**
metric						2	2			1	1	**3**
minimum standards		1	1	2		1	1	1	1	4	6	**9**
performance gap					1	1	2	1			1	**3**
quality assurance		1		1				2			2	**3**
recommendations	3	6		9		4	4	1	7	2	10	**23**
reporting									1		1	**1**
room in roof								1			1	**1**
traditional buildings		1		1	1		1					**2**
Grand Total	**3**	**10**	**1**	**14**	**2**	**8**	**10**	**7**	**11**	**7**	**25**	**49**

Format of the 'Recommended measures' table

Response Term [A.3]	Assessment		Total	Calculation		Total	Reporting		Total	Grand Total
	critical	*neutral*		*critical*	*neutral*		*critical*	*neutral*		
benchmarking					1	1				**1**
decarbonisation								2	2	**2**
metric					2	2				**2**
new technologies				2	1	3				**3**
performance gap				1	2	3		4	4	**7**
quality assurance		2	2		1	1				**3**
recommendations	1	5	6	3	7	10	3	12	15	**31**
reporting					1	1		3	3	**4**
room in roof							1		1	**1**
traditional buildings		2	2	1		1				**3**
Grand Total	**1**	**9**	**10**	**7**	**15**	**22**	**4**	**21**	**25**	**57**

SAP / RdSAP Metrics

Energy efficiency metrics and asset ratings

Response Term [A.3]	Assessment			Total	Calculation			Total	Database	Total	Reporting			Total	Grand Total
	critical	*neutral*	*positive*		*critical*	*neutral*	*positive*		*neutral*		*critical*	*neutral*	*positive*		
administration												1		1	1
affordable warmth												3		3	3
alternative model					1			1							1
awareness of SAP	1			1	2	1	1	4			4		31	35	40
benchmarking		4		4		1	1	2				2	2	4	10
conventions												1		1	1
database									2	2					2
decarbonisation					3	11		14				4		4	18
district heating		3		3		1		1			1			1	5
electric heating		2		2	1	7		8							10
embodied energy						1		1							1
flawed		2		2	8			8			6			6	16
fuel poverty					1	1		2			1	3		4	6
hard to treat		1		1											1
metric		5		5	15	19	1	35			5	2	19	26	66
minimum standards		2	1	3		1		1			2	1	5	8	12
performance gap	1	10		11	37	26		63			7	2	1	10	84
quality assurance		7		7	2			2			2	1		3	12
real data					2	1		3					1	1	4
recommendations	3	8		11	1	4		5			1	8	2	11	27
reporting						1		1				3		3	4
review and update					5	2		7			4		1	5	12
room in roof											1			1	1
surveyor skills	1	2		3											3
thermal imaging		1		1											1
traditional buildings		2		2	5	3		8				1		1	11
ventilation		1		1		2		2							3
Grand Total	**6**	**50**	**1**	**57**	**83**	**82**	**3**	**168**	**2**	**2**	**34**	**32**	**62**	**128**	**355**

Using real data

Response Term [A.3]	Assessment	Total	Calculation			Total	Database	Total	Reporting			Total	Grand Total
	neutral		critical	neutral	positive		neutral		critical	neutral	positive		
affordable warmth										1		1	**1**
alternative model			1	2		3				1		1	**4**
awareness of SAP			2	1	1	4			1		14	15	**19**
benchmarking	2	2									1	1	**3**
database							6	6					**6**
decarbonisation			2	1		3							**3**
district heating	1	1					3	3					**4**
electric heating				1		1							**1**
flawed	2	2	5			5			3			3	**10**
fuel poverty				1		1				1		1	**2**
metric	1	1	7	2		9			1	2	13	16	**26**
minimum standards											1	1	**1**
performance gap			6	2		8					1	1	**9**
real data			1	2		3					1	1	**4**
recommendations										1	1	2	**2**
reporting										2		2	**2**
review and update			1			1							**1**
thermal imaging	1	1											**1**
traditional buildings	1	1	1			1							**2**
ventilation				1		1							**1**
Grand Total	**8**	**8**	**26**	**13**	**1**	**40**	**9**	**9**	**5**	**8**	**32**	**45**	**102**

Occupancy factors

Response Term [A3]	Assessment	Total	Calculation			Total	Reporting			Total	Grand Total
	neutral		*critical*	*neutral*	*positive*		*critical*	*neutral*	*positive*		
affordable warmth								1		1	**1**
alternative model			1			1					**1**
awareness of SAP			2	1	1	4	1		14	15	**19**
benchmarking	1	1							1	1	**2**
conventions								1		1	**1**
decarbonisation			2	1		3					**3**
electric heating				1		1					**1**
flawed	2	2	5			5	3			3	**10**
fuel poverty				1		1		1		1	**2**
metric	1	1	8	5	1	14	1	2	15	18	**33**
minimum standards									1	1	**1**
performance gap			5	7		12		2	1	3	**15**
recommendations	1	1		1		1		1	1	2	**4**
reporting								4		4	**4**
review and update			2			2					**2**
traditional buildings			1			1					**1**
ventilation				1		1					**1**
Grand Total	**5**	**5**	**26**	**18**	**2**	**46**	**5**	**12**	**33**	**50**	**101**

Non-domestic Buildings

Categorisation of Consultation Responses (Non-Dom only) on Modelling

	Total Number of responses	source of response: LHEES consultation	source of response: SEEP consultation	source of response: PRS consultation
Calculation issues	192(13)	10(5)	74(8)	104(0)
Assessment issues	72(5)	9(1)	22(4)	41(0)
Reporting issues	116(5)	-	15(2)	101(3)
Database issues	4(0)	3(0)	-	1(0)
Total responses	394(23)	22(6)	111(14)	247(3)

Categorisation of Consultation Responses (Non-Dom only) on Methodology

	Total Number of responses	source of response: LHEES consultation	source of response: SEEP consultation	source of response: PRS consultation
Calculation issues	191(12)	11(5)	76(7)	104(0)
Assessment issues	78(6)	10(1)	22(5)	46(0)
Reporting issues	140(10)	2(0)	31(6)	107(4)
Database	2(0)	-	-	2(0)

issues				
Total responses	411(28)	23(6)	129(18)	259(4)

Categorisation of Consultation Responses (Non-Dom only) on Occupancy

	Total Number of responses	source of response: LHEES consultation	source of response: SEEP consultation	source of response: PRS consultation
Calculation issues	43(1)	3(0)	22(1)	18(0)
Assessment issues	11(0)	4(0)	4(0)	3(0)
Reporting issues	15(1)	-	8(0)	7(1)
Database issues	3(0)	3(0)	-	-
Total responses	72(2)	10(0)	34(1)	28(1)

Categorisation of Consultation Responses (Non-Dom only) on Convention

	Total Number of responses	source of response: LHEES consultation	source of response: SEEP consultation	source of response: PRS consultation
Calculation issues	10(0)	-	1(0)	9(0)
Assessment issues	20(0)	-	4(0)	16(0)
Reporting issues	11(0)	-	3(0)	8(0)
Database issues	0(0)	-	-	-
Total responses	41(0)	0(0)	8(0)	33(0)

Categorisation of Consultation Responses (Non-Dom only) on Location

	Total Number of responses	source of response: LHEES consultation	source of response: SEEP consultation	source of response: PRS consultation
Calculation issues	9(0)	-	3(0)	6(0)
Assessment issues	6(0)	0(0)	-	6(0)
Reporting issues	6(3)	-	1(3)	5(0)
Database issues	0(0)	-	-	-
Total responses	21(3)	0(0)	4(3)	17(0)

Categorisation of Consultation Responses (Non-Dom only) on Built Form

	Total Number of responses	source of response: LHEES consultation	source of response: SEEP consultation	source of response: PRS consultation
Calculation issues	16(1)	-	3(1)	13(0)
Assessment issues	20(0)	-	2(0)	18(0)
Reporting issues	8(1)	-	0(1)	8(0)
Database issues	0(0)	-	-	-
Total responses	44(2)	0(0)	5(2)	39(0)

Categorisation of Consultation Responses (Non-Dom only) on Condition

	Total Number of responses	source of response: LHEES consultation	source of response: SEEP consultation	source of response: PRS consultation
Calculation issues	0(0)	-	-	-
Assessment issues	12(0)	1(0)	3(0)	8(0)
Reporting issues	0(0)	-	-	-
Database issues	0(0)	-	-	-
Total responses	12(0)	1(0)	3(0)	8(0)

Categorisation of Consultation Responses (Non-Dom only) on Age

	Total Number of responses	source of response: LHEES consultation	source of response: SEEP consultation	source of response: PRS consultation
Calculation issues	0(1)	-	0(1)	0(0)
Assessment issues	3(0)	-	2(0)	1(0)
Reporting issues	0(0)	-	-	0(0)
Database issues	0(0)	-	-	-
Total responses	3(1)	0(0)	2(1)	1(0)

Categorisation of Consultation Responses (Non-Dom only) on Heating

	Total Number of responses	source of response:	source of response:	source of response:

		LHEES consultation	SEEP consultation	PRS consultation
Calculation issues	28(0)	2(0)	14(0)	12(0)
Assessment issues	8(0)	5(0)	1(0)	2(0)
Reporting issues	4(0)	-	3(0)	1(0)
Database issues	0(0)	0(0)	-	-
Total responses	40(0)	7(0)	18(0)	15(0)

Categorisation of Consultation Responses (Non-Dom only) on Energy Supply

	Total Number of responses	source of response: LHEES consultation	source of response: SEEP consultation	source of response: PRS consultation
Calculation issues	13(0)	-	8(0)	5(0)
Assessment issues	0(0)	-	-	0(0)
Reporting issues	1(0)	-	0(0)	1(0)
Database issues	0(0)	-	-	-
Total responses	14(0)	0(0)	8(0)	6(0)

Categorisation of Consultation Responses (Non-Dom only) on Fabric

	Total Number of responses	source of response: LHEES consultation	source of response: SEEP consultation	source of response: PRS consultation
Calculation issues	10(1)	-	2(1)	8(0)
Assessment issues	10(0)	-	2(0)	8(0)
Reporting issues	1(0)	-	-	1(0)
Database issues	0(0)	-	-	-
Total responses	21(1)	0(0)	4(1)	17(0)

Categorisation of Consultation Responses (Non-Domestic only) on Ventilation

	Total Number of responses	source of response: LHEES consultation	source of response: SEEP consultation	source of response: PRS consultation
Calculation issues	1(0)	0(0)	-	1(0)

Assessment issues	3(0)	0(0)	1(0)	2(0)
Reporting issues	0(0)	-	-	-
Database issues	0(0)	-	-	-
Total responses	4(0)	0(0)	1(0)	3(0)

Categorisation of Consultation Responses (Non-Dom only) on Improvements

	Total Number of responses	source of response: LHEES consultation	source of response: SEEP consultation	source of response: PRS consultation
Calculation issues	23(0)	-	7(0)	16(0)
Assessment issues	38(0)	2(0)	10(0)	26(0)
Reporting issues	69(1)	1(0)	11(0)	57(1)
Database issues	0(0)	-	-	-
Total responses	130(1)	3(0)	28(0)	99(0)

: Categorisation of Consultation Responses (Non-Domestic only) on Report

	Total Number of responses	source of response: LHEES consultation	source of response: SEEP consultation	source of response: PRS consultation
Calculation issues	24(1)	-	8(1)	16(0)
Assessment issues	37(2)	1(0)	10(2)	26(0)
Reporting issues	69(3)	-	11(2)	58(1)
Database issues	0(0)	-	-	-
Total responses	130(6)	1(0)	29(5)	100(1)

Categorisation of Consultation Responses (Non-Domestic only) on Assessor

	Total Number of responses	source of response: LHEES consultation	source of response: SEEP consultation	source of response: PRS consultation
Calculation issues	4(0)	-	2(0)	2(0)
Assessment issues	91(1)	0(1)	21(0)	70(0)
Reporting issues	7(0)	-	4(0)	3(0)

Database issues	0(0)	-	-	-
Total responses	102(1)	0(1)	27(0)	75(0)

Categorisation of Consultation Responses (Non-Dom only) on Data Storage and Retrieval

	Total Number of responses	source of response: LHEES consultation	source of response: SEEP consultation	source of response: PRS consultation
Calculation issues	4(3)	1(3)	3(0)	-
Assessment issues	1(0)	0(0)	-	1(0)
Reporting issues	1(0)	-	-	1(0)
Database issues	7(0)	3(0)	-	4(0)
Total responses	13(3)	4(3)	3(0)	6(0)

Assessors

Categorisation of Consultation Responses on Assessors

	Total Number of responses	Number of critical responses	source of critical response: LHEES consultation	source of critical response: SEEP consultation	source of critical response: PRS consultation
Calculation issues	0	0	0	0	0
Assessment issues	278	12	0	6	6
Reporting issues	8	2	0	1	1
Database issues	0	0	0	0	0
Total responses	286	14	0	7	7

Categorisation of Consultation Neutral Responses on Assessors

	Number of neutral responses	source of neutral response: LHEES consultation	source of neutral response: SEEP consultation	source of neutral response: PRS consultation
Calculation issues	0	0	0	0
Assessment issues	265	2	23	240
Reporting	6	0	0	6

issues				
Database issues	0	0	0	0
Total responses	271	2	23	246

Rooms in roof

Categorisation of Consultation Responses on Rooms in the Roof

	Total Number of responses	Number of critical responses	source of critical response: LHEES consultation	source of critical response: SEEP consultation	source of critical response: PRS consultation
Calculation issues	1	0	0	1	0
Assessment issues	4	2	0	0	2
Reporting issues	3	1	0	0	1
Database issues	0	0	0	0	0
Total responses	8	3	0	1	3

Categorisation of Consultation ‘Non-critical’ Responses on Rooms in the Roof

	Number of neutral responses	source of neutral response: LHEES consultation	source of neutral response: SEEP consultation	source of neutral response: PRS consultation
Calculation issues	1	0	1	0
Assessment issues	2	0	0	2
Reporting issues	2	0	0	2
Database issues	0	0	0	0
Total responses	5	0	1	4

Community heating

Categorisation of Consultation Responses on District Heating, Community Heating

Issue	Total Number of responses	Number of critical responses	source of critical response: LHEES consultation	source of critical response: SEEP consultation	source of critical response: PRS consultation
Calculation issues	11	5	0	3	2

Assessment issues	0	0	0	0	0
Reporting issues	3	0	0	0	0
Database issues	1	0	0	0	0
Total responses	15	5	0	3	2

Categorisation of Consultation 'Neutral' Responses on DH/CHP

	Number of neutral responses	source of neutral response: LHEES consultation	source of neutral response: SEEP consultation	source of neutral response: PRS consultation
Calculation issues	6	6	0	0
Assessment issues	0	0	0	0
Reporting issues	3	0	0	3
Database issues	1	1	0	0
Total responses	10	7	0	3

Ventilation

Categorisation of Consultation Responses on Ventilation

	Total Number of responses	Number of critical responses	source of critical response: LHEES consultation	source of critical response: SEEP consultation	source of critical response: PRS consultation
Calculation issues	3	0	0	0	0
Assessment issues	8	1	0	0	1
Reporting issues	0	0	0	0	0
Database issues	0	0	0	0	0
Total responses	11	1	0	0	1

Categorisation of Consultation 'Neutral' Responses on Ventilation

	Number of neutral responses	source of neutral response: LHEES consultation	source of neutral response: SEEP consultation	source of neutral response: PRS consultation
Calculation issues	3	1	0	2
Assessment issues	7	1	1	5
Reporting issues	0	0	0	0
Database issues	0	0	0	0

Total responses	10	2	1	7

Measuring windows

Categorisation of Consultation Responses on Glazing

	Total Number of responses	Number of critical responses	source of critical response: LHEES consultation	source of critical response: SEEP consultation	source of critical response: PRS consultation
Calculation issues	0	0	0	0	0
Assessment issues	3	0	0	0	0
Reporting issues	2	0	0	0	0
Database issues	0	0	0	0	0
Total responses	5	0	0	0	0

Categorisation of Consultation 'Neutral' Responses on Glazing

	Number of neutral responses	source of neutral response: LHEES consultation	source of neutral response: SEEP consultation	source of neutral response: PRS consultation
Calculation issues	0	0	0	0
Assessment issues	3	0	0	3
Reporting issues	2	0	0	2
Database issues	0	0	0	0
Total responses	5	0	0	5

This publication is available at **www.gov.scot**

Any enquiries regarding this publication should be sent to us at
The Scottish Government
St Andrew's House
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ISBN: 978-1-78781-542-1 (web only)

Published by The Scottish Government, January 2019

Produced for The Scottish Government by APS Group Scotland, 21 Tennant Street, Edinburgh EH6 5NA
PPDAS525346 (01/19)