A REPORT ON THE LIKELY MAINSTREAM TECHNOLOGIES IN THE MID 2020's THAT SAP11 WILL NEED TO CONSIDER

This report has been written at the request of BEIS as part of the Lot 4 "Quality Assurance of SAP Model"

The report was developed by the SAP INDUSTRY FORUM, which is jointly owned by BRE and Robust Details Limited.

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Full details of the SAP Industry Forum including its membership and terms of reference may be found at https://www.bregroup.com/sap/sap-industry-forum/

BRE and RDL wish to record their thanks to all the members of the SAP Industry Forum and the Working Groups who generously gave their time and expertise to develop this report.

SAP 11 Technologies Report

SAPIF report – collated by John Tebbit (RDL), Nick Booth (RDL) and John Henderson (BRE)

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Acronyms

BEIS	Department for Business, Energy and Industrial Strategy
BIM	Building Information Modelling/Management
BRE	Building Research Establishment
DAs	Devolved Administrations (Northern Ireland, Scotland & Wales)
DHW	Domestic Hot Water
IAQ	Indoor Air Quality
MHCLG	Ministry of Housing, Communities and Local Government
SAP	Standard Assessment Procedure
SAPIF	SAP Industry Forum
SAPSIG	SAP Scientific and Integrity Group
TOU	Time of use
URN	Unique Reference Number
WGs	SAP Industry Forum Working Group

1. INTRODUCTION

BEIS, who have primary responsibility for the development of SAP for all its uses, asked the SAP Industry Forum in October 2018 to produce a report to help inform the development of the next major iteration of SAP. That version, SAP11, would be expected to come into use in the mid 2020s subject to the usual consultation and development processes. This report is primarily designed to be a briefing document for BEIS and any potential developer of SAP11, although it is hoped that it will be of use to other interested parties.

To aid readability, the reports from the Working Groups and SAPSIG are reproduced in full in the Appendices. Short summaries of key points are included in this Executive Summary.

The reports give *inter alia* details of the expected technologies, how they work, relevant standards, sources of performance data and suggested ways to model the technologies. Some of the technologies are, in the views of the WGs, well modelled in SAP10, whilst others are either not so well modelled or do not feature at all. There is a general sense that SAP needs to bring innovative products into the main specification more quickly and effectively than at present. The present system is via Appendix Q. There is a view that the Appendix Q process is restricting innovation due to what some WGs see as overly onerous and academically biased processes to demonstrate product performance. However it is recognised that such changes would not be simple to implement.

Many of the groups have also commented on the underlying methodology of SAP in a more dynamic and complex world with different scales and types of energy storage, time of use tariffs and smart technology. There is a sense that SAP with its monthly average model and single occupancy model is not aligned with the 'smart' grid, storage, appliances and controls world.

There are concerns over the affordability of energy for occupiers if Part L does not include an affordability criterion. Therefore SAP needs to be a good predictor of likely energy costs in the new dynamic, smart energy world as well as energy used.

This report also includes views from the SAP Scientific Integrity Group on what it sees as necessary improvements to the SAP model, as well as reports from interviews with officials from the Devolved Administrations. There is a summary of key points from the co-chairs of SAPIF, John Henderson of BRE (SAP Contract Lots 1, 2 and 3) and John Tebbit of Robust Details (SAP Contract Lot 4).

It must be made clear at this stage, that this report is primarily concerned with recording the range of views, some of which are contradictory. The report's authors have deliberately not edited the industry reports from the WGs for fear of losing information. It will be for others further along in the SAP11 development process to make the choices where there are differing views.

Finally, it must be emphasised that the views stated in this report are, unless specifically stated otherwise, those of the SAPIF working groups, SAPSIG members, Devolved Administrations or the co-chairs. They should not be taken in any way to be BEIS or MHCLG views.

2. BACKGROUND AND OBJECTIVES

The SAP Industry Forum was established in Q1-2 2018 to assist with BEIS' policy of engagement with industry. SAP contract discussions (BEIS, BRE and Robust Details) resulted in the first SAP Industry Forum meeting June 2018, during which industry identified a number of topics that concerned them.

These were distilled into five key subject topics (which led to the five Working Groups), plus some other aspects (e.g. BIM).

The BEIS policy team asked the SAP Industry Forum in (October 2018) to work on establishing the likely technologies that would be mainstream for housing in the mid 2020s. As previously mentioned, there is a view from industry that SAP is slow to incorporate new technologies either via Appendix Q or in the main specification. Asking industry to set out likely technologies was seen as a way to increase the chances of SAP11 covering all the likely technologies including innovative solutions that might not otherwise be known to the future SAP11 contractor. Another reason was to improve the quality of communication between government, SAP contractor and industry, not just for this project but also for any other issues that could arise.

A formal set of objectives was established and five working groups set up.

The objectives were:

1. To establish the state of the art, sources of information and basic explanations of the technologies/systems expected to be mature in the mid 2020's
2. To propose some modeling criteria for the performance of the technologies and secondly how compliance could be judged at both product and dwelling level.
3. If government decides to include recognition of the technology or system in SAP11, to work with government and the SAP contractor to develop the details

The five working groups were:

- WG1 Domestic Hot Water, heating and 1-day hot water storage
- WG2 Smart controls, technologies and tariffs
- WG3 Home Energy Storage (longer than one day)
- WG4 Overheating including prevention and cooling
- WG5 Ventilation and Indoor Air Quality

In addition, the co-chairs undertook to look at a high level, digital construction issues.

Later in the project, it was decided by the co-chairs to ask the SAP Scientific Integrity Group for their views on the development of SAP11.

The initial SAP Industry Forum meeting (held June 2018) was widely attended by industry. This was followed by a focussed second meeting in October 2018 during which the leaders of the five Working Groups were identified. Subsequently, a further five meetings were held, either as Working Group leaders only or full membership; to maintain momentum and ensure inter-working group activity. BEIS, MHCLG and Devolved Administrations were engaged in all of these meetings. Minutes and presentations are available via the BRE hosted SAP website[1].

3. SAPIF WG REPORTS

The co-chairs are of the view that attempting to draw more than the most high-level conclusions from the five Working Group reports is both difficult and probably misleading. Therefore, the full reports are reproduced in Appendices 8a to 8e of this report and the following summaries should be seen more as a description of content than a representation of views.

[1] https://www.bregroup.com/sap/sap-industry-forum/

WG1 Domestic Hot Water and Heating
The report sets out the current main technical solution (gas condensing boiler), details on DHW consumption by use, the increasing use of Time of Use (TOU) tariffs and the electrification of heating and DHW, primarily via heat pumps. There is a section on decarbonisation of the gas grid.

The main recommendation is that the 'fixed' model of SAP with assumptions on occupancy, usage patterns, heat and DHW demand needs looking at in a more dynamic market. The WG looks at technologies such as demand side response for heat and DHW, peak shaving and load shifting using DHW storage, variable pricing of fuel via TOU tariffs and better use of local generation.

The report sets out the various technologies, definitions, present status in SAP, relevant standards, modelling proposals and case studies. There is a call for an improved Product Characteristic Database (PCDB) to aid SAP Assessors.

WG2 Smart Technologies
The report notes the wide range of technologies that can be described as 'smart' and references the Smart Readiness Indicator work being done at European level. Much of the report covers clear definitions of technologies and products.

It is acknowledged that smart controls by their very nature are driven by occupant behaviour and vice versa. This is the recognised fundamental issue for the existing SAP model, that assumes a standard occupancy and behaviour.

The difference between modelling for design and modelling for compliance is discussed.

There is a list of technologies, their various degrees of smartness and reference to some case studies on energy savings.

WG3 Energy Storage
The impact of Home energy storage solutions on a building energy performance cannot be simply assessed using the existing SAP approach. Strongly recommend, proper research work is conducted on how energy storage technologies are accurately assessed by SAP or any other tool, to avoid deceleration of technology advancement and innovation.

Main findings & recommendations:

1. Energy storage technologies have a critical role to play in delivering energy security, energy and carbon commitments. Use of energy storage in homes, combined with smart control strategies, will ease pressure on the already stretched energy networks and enable new low carbon heating solutions to be adopted.
2. SAP cannot asses the dynamic interaction of different technologies used in terms of energy storage and align those with specific utilisation patterns; Move from static to dynamic house energy and carbon performance evaluation.
3. A rebranded SAP & EPC should be considered, synthesising with energy system market reforms to decarbonise heat and as an indicator of fuel poverty. Peak demand can be reduced through several means including higher fabric standards, thermal or battery storage or using advanced control systems. Consideration should be given to how a future SAP can be used as a policy lever, "unlocking" market barriers behind and in front of the meter.
4. Further consultation with Ofgem and others is necessary to deliver a net zero economy at lowest cost to consumers; enabling competition and innovation, both of which drive down prices and result in new products and services for heat.

WG4 Overheating and Cooling
The report starts by setting out the principles of why overheating occurs. It then describes the main technologies that mitigate overheating, namely glazing, shading, thermal mass and ventilation. It also includes glazing technologies that can generate energy as well as mitigate overheating.

Each is then analysed to see how well it is modelled in SAP and what needs to be updated, particularly as new technologies arrive.

The WG has produced several supporting documents to their report and there are extensive links to further information.

WG5 Ventilation and IAQ
The report looks at how various ventilation systems are modelled in SAP. Due to the construction of Approved Document F of the building regulations the volume of airflow is fixed and the WG view is that there is therefore limited benefit to be gained from new technologies. These requirements need to change so that there is some relationship between on the one hand varying transient occupancy rates and/or ownership of the dwelling and on the other hand an ability to vary the set ventilation levels between the regulated minimum ventilation rates and higher rates that are required when it is determined or sensed that the Indoor Air Quality has declined. Without this change in the requirements, it is unlikely that innovative energy saving products will come to market.

Control standards are discussed along with on-going work on European Standards and Ecodesign.

A major issue for the industry is quality of design, installation, commissioning and compliance. At present SAP does not recognise any scheme in terms of giving a benefit in its output metrics.

4. SAPSIG VIEWS

The report from the discussions with SAPSIG is included as Appendix 8f. The key points are reproduced below.

1. There are pros and cons for moving SAP11 from a monthly average to a dynamic (half hour demand) model and such a move should be considered. Alternatively, there is a case for reducing SAP back to a much simpler steady-state model and to use mainstream dynamic simulations for the more dynamic features that will become increasingly necessary in future energy scenarios.
2. Whilst assessment of overheating risk could be part of SAP it is unlikely that SAP could become the tool that allows designers to fully assess and mitigate overheating.
3. There does not appear to be any fundamental problem for SAP to model new shared technologies such as communal energy storage or load shifting. SAP already does similar things.
4. Until there is certainty that the as-built data being entered into SAP accurately reflects what is actually physically built, the ‘Performance gap’ will remain. It would arguably be a waste of public money to further develop SAP without also sorting out this fundamental problem.
5. Consideration needs to be given to a better coordination and funding of research, possibly via a contribution from industry via an EPC levy.
6. The governance and operation of SAPSIG needs reviewing, given the voluntary nature of the group and the increasing complexity of the questions being put to it.

5. DEVOLVED ADMINISTRATION INTERVIEWS

The report of the interviews by the co-chair John Tebbit with officials from the DAs is included as Appendix 8g. For England, the authors have taken it that MHCLG views are dealt with via the existing links with the BEIS team.

There were no major strategic issues raised. Ideas included localisation of Appendix T for recommended improvements, local electricity factors and better interoperability of data and URNs.

6. DIGITAL CONSTRUCTION AND SAP

The main point to emerge from discussions, was the need to ensure that data could be easily and accurately transferred between various software systems. At a basic level this means adopting standard terms and definitions for all items e.g. windows, doors, dimensions, services. It is strongly recommended that the relevant industry BIM groups are involved from the start of the SAP11 development process to ensure that this is done.

7. SUMMARY AND KEY POINTS

There are a few high-level points that come across in many if not all the reports. These are briefly mentioned below, more for the record than in any attempt to answer them. That, as has been stated earlier, is for others to attempt at a later date.

Smart, load shifting and TOU Tariffs

The first general point identified by the WGs is that the energy system is becoming ‘smarter’ with energy suppliers looking to use time of use (TOU) tariffs to try and change consumer behaviour. Put simply, if energy prices are high at peak times, it is expected that consumers will, to a greater or lesser extent, shift energy use to times with a lower price. Much of this shifting will be facilitated by smart controls that will automatically modify energy use, but not overall consumption. Price might not be the only driver; carbon intensity might also be used. There are arguments as to whether price (through a TOU tariff) might be a good proxy for carbon intensity in any case. This is because at times of high electricity demand in general more fossil fuel power stations are brought on line. Price is also higher at periods of high demand via TOU tariffs e.g. the Octopus Agile tariff.

This time shifting of energy use is typically thought of as being within a 24 hour period but technologies are being developed that will more easily allow storage and hence shifting over longer periods up to perhaps, inter seasonal. So for example summer energy could be stored for winter use.

The above is part of the bigger question as to how TOU tariffs, energy storage and changes in occupier behaviour are dealt with in SAP. Some WGs argue for a fully dynamic half hour modelling approach to model this behaviour. This would allow TOU tariffs to be taken into account, for energy storage to be modelled and interactions between various systems e.g. hot water, ventilation, energy storage to be better understood, particularly when occupant behaviour is expected to change due to price signals. SAPSIG thought that dynamic half hour modelling should be considered but noted both pros and cons.

Being able to model a wide range of behaviour could be useful for showing occupants how changes in behaviour or new technology could save energy and/or money. However, at present compliance for

Part L is on the empty dwelling before occupancy, hence a standard occupancy and behaviour is assumed.

Hot water – the dominant energy use in new homes
Another point is that in new homes hot water use is becoming the dominant energy use. Historically it was heating and SAP has developed considerable complexity and sophistication over the years in how it deals with heating.

There is not that complexity or sophistication for hot water. The data on hot water usage is relatively old and it is believed that there is considerably more variation in hot water usage between ostensibly similar occupiers in similar homes than for heating. While hot water was a minor energy use, this was not seen as important. With hot water becoming the major energy user, the SAPIF WGs see the need for better modelling of it.

It is further complicated by the fact that hot water can/could be part of an energy storage/load shifting system and have TOU tariffs.

Compliance and modelling – the key distinction
As mentioned above, many of the WGs argue for modelling of more complex behaviours, typically due to smart controls and sometimes occupants changing behaviour in response to price signals. There is a need in the co-chairs‘ view to clearly distinguish between two very different things.

The first is a generally wanted ability of SAP11 to more accurately model different usage/behaviour/TOU tariff scenarios. This could be addressed by having for instance, a usage/behaviour/TOU tariff scenario data sheet where different sets of behaviour and usage could be set out and rapidly put into SAP11 in succession to give the various results. That might be very useful when showing occupants how different tariffs or behaviours could alter their energy use.

The second is the question of how compliance with Part L for example is judged. At present compliance for Part L is on the empty dwelling before occupancy. So a standard occupancy and behaviour is assumed. Indeed SAP10, can model this.

Industry knows that house builders build their homes to be compliant with Part L, using SAP. Technologies that offer cost effective ways to achieve compliance under the standard occupancy and behaviour are therefore commercially favoured. Technologies that possibly save occupants money under different scenarios to the compliance scenario may therefore have that commercial disadvantage, including many innovative technologies, particularly ‘smart’ and load shifting.

The WGs appear to believe that by having a more complex and dynamic model of the dwelling, the advantages of such technologies could be better modelled. However, the question in the co-chairs’ mind is how compliance could be judged for a dwelling with these technologies that by their very definition change occupants’ behaviour or adapt to it.

It should be noted that dwellings designed and built using the Passive House Planning Package (PHPP), which is a monthly average model, have been shown to perform on average as predicted.

Overheating and compliance checking
There was agreement that the current overheating check in SAP was not that good. Both SAPSIG and WG4 agreed on the need for improvement. The question remains as to the best place for the initial check on whether the dwelling is at risk and then the more detailed assessment of risk and design

alterations to mitigate the risk and, if necessary, measures to cool the dwelling. WG4 lists much of the relevant work being done at present.

SAPSIG was of the view that SAP was the place to assess the risk, possibly a Red, Amber, Green style output. Then more specialised tools should be used to look at options to reduce the risk.

Quality of data being entered into SAP

SAPSIG in particular, was extremely concerned about the continuing poor quality of data being entered into SAP for both Part L compliance and EPCs. Whilst strictly not a BEIS responsibility, there was a strong view that spending money on developing SAP without first ensuring a reasonable level of quality control on the data, could be seen as wasting money. This ties in with the wider debate (see Hackitt) on compliance.

8. Appendices

Appendix 8a – WG1 Domestic Hot Water, heating and 1-day hot water storage

Appendix 8b – WG2 Smart controls, technologies and tariffs

Appendix 8c – WG3 Home Energy Storage (longer than one day)

Appendix 8d – WG4 Overheating including prevention and cooling

Appendix 8e – WG5 Ventilation and Indoor Air Quality

Appendix 8a

WG1 Domestic Hot Water, heating and 1-day hot water storage

Executive Summary

This report sets out the current main technical solutions in use today together with detail on DHW consumption by use.

The main recommendation is that the ‘fixed’ model of SAP with assumptions on occupancy, usage patterns, heat and DHW demand needs to be re-evaluated to better represent a more dynamic energy market. The working group explored technologies such as demand side response for heat and DHW, peak shaving and load shifting using DHW storage, variable pricing of fuel via time of use tariffs and better use of local generation, including energy saving technologies.

Feedback from the working group, in addition to the prescribed scope, includes the need for increased transparency on implementation compared to current methodology, more scrutiny on how the model operates and a simpler route for new technology to be adopted into the SAP framework. The current Appendix Q method is thought to represent an artificially high barrier to entry, which only serves to stifle innovation.

Scope and Terms of Reference

The SAP Industry Forum (SAPIF) set out a task to primarily identify the technologies and systems expected to be adopted in buildings during the mid-2020's, which may need to be accounted for within the SAP 11 calculation framework. Several working groups were established to explore specific technology sectors expected to undergo change.

This working group focuses upon both the heating and storage of water, with all heating technologies nominally in scope. Given the potential duplication of effort with other working groups, including one dealing with long-term energy storage, it was decided early on that the group would concentrate upon short-term storage, or 'intra-day' storage. Furthermore, systems incorporating warm air or integration with ventilation have not been considered owing to potential overlap with the ventilation working group.

Although domestic hot water will represent a much larger proportion of regulated energy in future, as building fabric standards invariably tighten, the group felt it important to keep space heating under consideration. This is not only important for new buildings but also the estimation of energy performance of existing buildings under the RDSAP framework, the methodology for which is expected to be derived from the main SAP specification as per usual.

The main objectives and outputs of this group based around the requirements from SAPIF were agreed as:

1. A list of any new/additional systems/technologies the group think should be included in SAP 11
2. Practical definitions and explanations of each system/technology, including sub-categories
3. Information sources relevant to developing any new/additional methodology required
4. The group's comments on any broader issues likely to impact on the approach taken in SAP or the wide applicability of a system/technology
5. Initial thoughts on modelling approaches for new/additional technologies/systems

Group Input and Membership

A wide-ranging group of representatives from industry participated in working group meetings over the course of 2019, collaborating to provide input to this report (refer to Appendix 2 for a list of group members). To encourage input from across all technologies input was sought from a variety of trade associations including:

- The Heating and Hot Water Industry Council (HHIC)
- The Hot Water Association (HWA)
- The Solar Trade Association (STA)
- The British Electrical and Allied Manufacturers Association (BEAMA)
- The Heat Pump Association (HPA)
- The Manufacturers of Equipment for Heat Network Association (MEHNA)

Whilst industry has been consulted widely there is always the possibility, although not by design or intent, that some interested or relevant parties are not represented. Furthermore, the very nature of new technology development entails a degree of sensitivity, intellectual property protection and competitive advantage. As such this report cannot be considered as an exhaustive or comprehensive reference.

All parties attending working group meetings were reminded that representatives from the Department for Business Energy and Industrial Strategy (BEIS) can be approached in private to discuss any commercially sensitive technology development work that could be relevant to the task.

Heat and Hot Water – The Current Situation

Most mainstream developer new build specifications currently incorporate a condensing gas fired combination boiler to provide both space heating and domestic hot water (DHW) provision owing to compact dimensions, comparatively low CAPEX and low OPEX costs.
It is anticipated that government policy and regulatory change will drive a wider diversity of technology across the sector during the lifespan of SAP 11 with hot water becoming more important as part of the regulated energy envelope.
Under the current National Calculation Methodology (NCM), SAP 2012 V9.92, a range of representative dwelling types were analysed to determine the current distribution of calculated regulated energy demand – as demonstrated in figure 1 below:

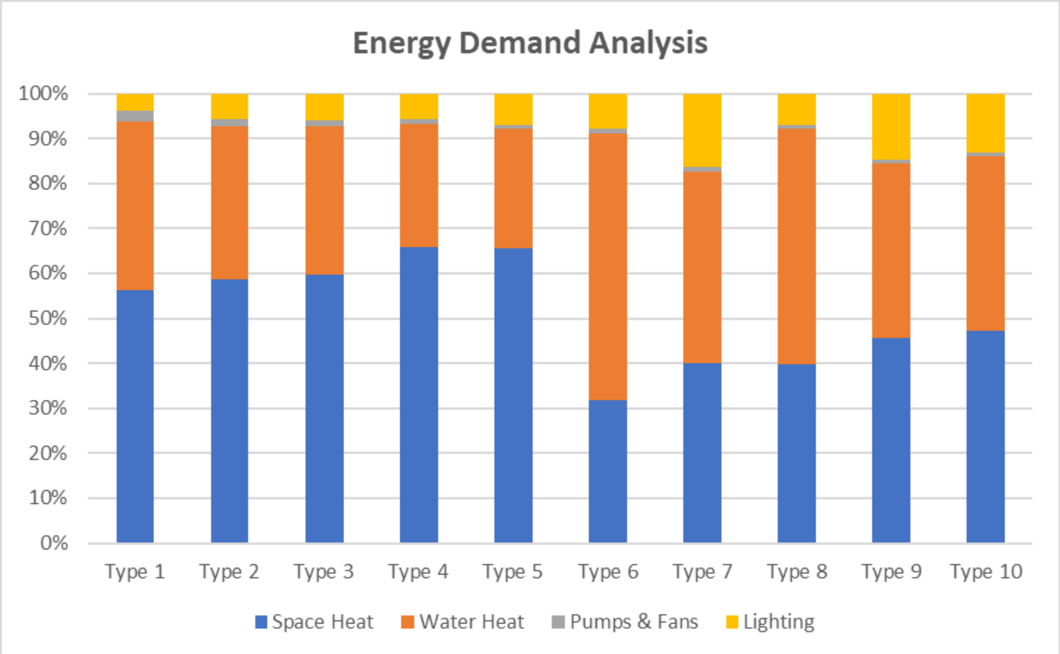


Figure 1

Taking an average of these dwellings, see figure 2, it is clear that hot water is currently a secondary consideration in comparison to space heat.

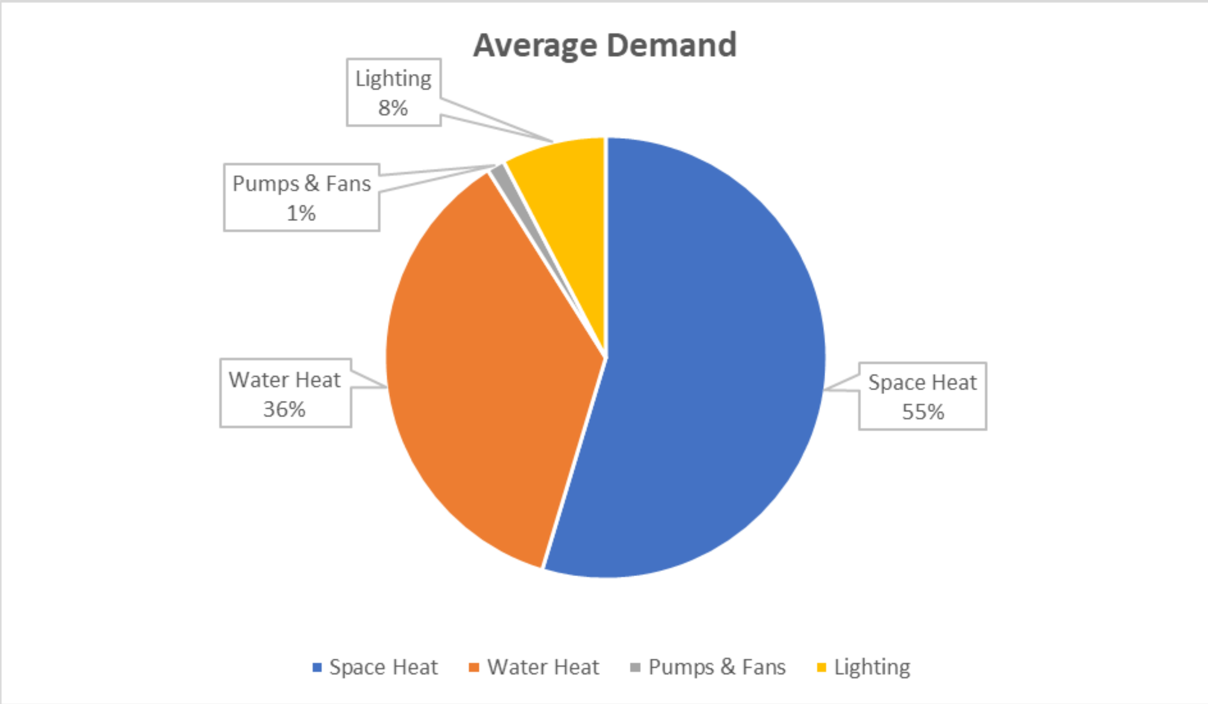


Figure 2

Starting with upcoming changes to Approved Document L of the Building Regulations and subsequent uplifts expected under the 'Future Homes Standard' it is expected that fabric heat loss and air leakage rates will become progressively tighter in order to meet reduced energy demand targets. As such domestic hot water provision will become the main regulated energy demand in all but the largest of house type designs.

As such there was a group consensus that the SAP methodology for hot water demand and use is somewhat basic in comparison to the far more comprehensive treatment of space heating demand.

With this increased focus on water the differing use cases for consumption within a dwelling also require greater consideration than current, this is influenced by factors such as the type of system, rejected water volume and differences in pipework distribution.

A 2013 study by the Energy Saving Trust[2], including data from 86,000 households, provided insight into the split of hot water consumption by use in households, as shown in figure 3 below. This analysis would support the proposition that heat recovery from showers is an important forward consideration.

[2] https://www.energysavingtrust.org.uk/sites/default/files/reports/AtHomewithWater(7).pdf

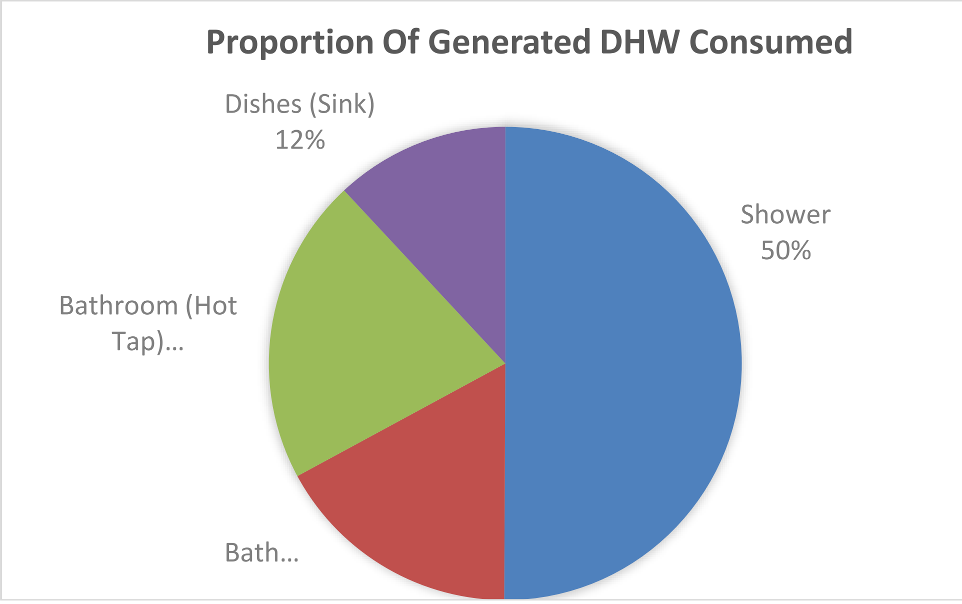


Figure 3

A diversification in the market away from combination boilers will also drive installation of stored hot water, which will be a necessity with most alternative systems. Again, the group thought that the current treatment within SAP for hot water storage could be built upon to better reflect a wider selection of use cases.

Relevant Standards

The heating and hot water market is highly regulated with a well-established standards framework. Most of the product types within the remit of this working group are regulated under the EcoDesign of Energy Related Products Directive framework which determines performance requirements and references relevant harmonised standards to demonstrate such:

- Space heating is captured under EU Regulation 813/2013[3]
- Water heaters and storage tanks are captured under EU Regulation 814/2013[4]

In support of the EcoDesign framework, a comprehensive techno-economic and environmental assessment of water use, including water heating, was developed by the European Commission's Joint Research Centre (JRC). The final research report[5] should be considered a key information source for any future SAP development in the hot water field.

Current government policy proposals in the new build sector indicate a preference towards lower operating temperatures for heating systems, coupled with a move toward hot water storage resulting from alternative heating technologies. Due consideration must be given to legionella control, typically via thermal disinfection, which will increase energy use in the SAP framework. Established guidance from

[3] https://ec.europa.eu/growth/single-market/european-standards/harmonised-standards/ecodesign/space-heaters_en
[4] https://ec.europa.eu/growth/single-market/european-standards/harmonised-standards/ecodesign/water-heaters-and-hot-water-storage-tanks_en_en
[5] https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/meerp-preparatory-study-taps-and-showers-final-report

the Health and Safety Executive (HSE)[6] and the Chartered Institute of Building Services Engineers (CIBSE)[7] provide a good reference point in this regard.
Given the diversity of product and system types within the scope of this working group relevant specific reference standards are referenced in appendix 1.

Technology List

The following technology types were considered and debated by the working group:

- Hot Water Cylinders (all use cases, including demand side response and smart grid connected)
- Thermal Stores and Combined Primary Storage Units
- Combination, System and Regular Boilers including Flue Gas Heat Recovery (FGHR)
- Combination, System and Regular Boilers with low carbon fuels
- Heat Pumps
- Heat Pumps (hybrid)
- Combined Heat and Power (all types, including engine, fuel cell and alternatives)
- Waste Water Heat Recovery (WWHR)
- Heat Networks and Heat Interface Units (HIU)
- High Efficiency Showers
- Solar Thermal
- Solar Photovoltaic (PV)
- Point of Use Water Heaters (single and multipoint)

In many cases the existing SAP 10 framework recognises and caters for these technologies, with some groups represented in the SAP Product Characteristics Database (PCDB), therefore much of the debate surrounded refinements to current methodology rather than a need for specific new technology categories.

Overarching Recommendations

The current and historic versions of the SAP framework are based upon a fixed model, with assumptions made over occupancy, usage patterns, heat and hot water demand. When based upon fixed energy vector(s) in terms of unit price, carbon intensity and primary energy values this is not a particular issue. However, as electrically driven heat is expected to play a larger part in the new build sector under the proposed 'future homes standard' the group felt that a fixed model is no longer relevant.
A dynamic and flexible calculation model is expected to become more relevant to reflect the variability of supply conditions and interaction between the dwelling and smart grid in future as occupiers become 'prosumers' in the energy system.

[6] https://www.hse.gov.uk/legionnaires/
[7] https://www.cibse.org/knowledge/knowledge-items/detail?id=a0q20000008I7lfAAC

Points for consideration largely centre upon the potential for smart grid interactions, such as:

- Demand side response for space heat and DHW
- Peak shaving and load shifting using addressable hot water storage
- Time of use tariffs and half hourly metering, leading to variable unit pricing throughout the day
- Better management of embedded local generation to promote self-consumption

Importantly smart control, or automation of such functionality, will mean that energy saving benefit is derived irrespective of consumer input.

As such a clear recommendation is that SAP 11 should include the ability to model and derive adequate, yet accurate, DER/DPER compliance benefit for specifiers/developers to promote inclusion of new technologies.

Secondary heating was raised as a point for discussion, in that a move to lower temperature primary heating systems may see developers choosing to specify an electric focal fireplace in living rooms in order to alleviate concerns over customer comfort. To address the potential impact on running costs, it was thought that the calculation of secondary heating input requires some attention.

Another issue raised by the group is the potential for lower carbon intensity and primary energy factors offered by green gas, hydrogen and bio-fuels.
Whilst the 'Future Homes Standard' announcement and direction of travel talks about 'clean heat' the definition of such is yet to be agreed. As such the group felt that the SAP framework should be completely technology agnostic.

Zero carbon fuels are developing for current technologies and once they become available in the market, they can be an integral part of technology solutions. For the gas grid; bio-methane injection and in the future hydrogen injection, through projects such as HyDeploy[8] and HyNet[9], should result in a reduction of the current intensity values detailed in table 12 of the SAP manual during the expected lifespan of SAP 11. Similarly, bio-LPG[10] and bio-oil[11] in the off-grid sector are being developing and considered.

The emerging decarbonisation of the 'whole energy system' in a 'multi-vector' way should be considered, which offers limitation of household disruption and economic benefits through the balancing of renewable electricity and decarbonised gas supply sources and existing distribution grids[12].

In addition to the general SAP methodology for hot water requiring refinement and updating, the issue of modelling versus reality generated a great deal of debate. In the new build sector, most developers are NHBC registered and are required to follow requirements of NHBC Standards in order to maintain warranty cover.

NHBC Standards Section 8.1.5[13] dictate flow rate and temperature requirements for specific outlets which are in excess of those included in current SAP methodology – it is considered essential that the model is addressed in line with standard industry practice in order to address this discrepancy.

[8] https://hydeploy.co.uk/
[9] https://hynet.co.uk/
[10] https://www.shvenergy.com/biolpg/
[11] https://www.oftec.org/future-heating
[12] http://www.energynetworks.org/assets/files/gas/Navigant%20Pathways%20to%20Net-Zero.pdf
[13] https://nhbc-standards.co.uk/8-services/8-1-internal-services/8-1-5-hot-water-service/

As a continuing discussion point within the industry, the issue of SAP Appendix Q was raised by the group, with a consensus that the current process, and required level of validated field trial data, presents an unreasonable barrier to market. As an alternative approach the idea of a supported field trial route for a limited number of installations to gain the required level of validation was considered. Given this topic is outside of the scope of the working group output a follow up meeting to explore this topic further would be preferable.

Appendix 1 – Technology Specific Detail and Recommendations

Hot water cylinders and thermal stores:

The main points raised in respect to this product group were:

- Recognition for smart grid use cases
- The need for a PCDB category in order to simplify assessor modelling and provide scrutiny of performance claims

There are several sub-types within the category as detailed in the below tables.

Technology Type	Hot water cylinder - Demand Side Response enabled
Methodology Included in SAP 10	Yes, but for "conventional" cylinders only
Product Category on PCDB	No
Description of technology function including any limitations *(supplementary schematics or diagrams on separate sheets)*	Cylinder optimised for demand side management - integration with controls and communications technology that allows energy providers to interrogate and access hot water energy storage capacity when there is excess grid generation (usually from renewables input)
Relevant BS / EN or other performance standards	Established series of product safety and constructional standards depending on type (e.g. EN 12897, EN 60335-2-21). Performance standards established for the purposes of ErP rating do not cover this mode of operation - only consider "conventional" energy inputs
Smart Grid / ToU benefit to performance?	Yes. Controls will sense energy capacity of the cylinder and communicate information to energy provider. When excess grid generation is available a communication from the energy provider remotely switches on an immersion heater within the cylinder to heat water using low carbon generated energy
Modelling Proposals *(supplementary document if needed)*	Not known
Case Study or other supporting data? *(supplementary document if needed)*	A number of pilot studies are in operation or development so data should be/become available prior to SAP 11

Technology Type	Heat Pump optimised Hot water cylinder
Methodology Included in SAP 10	Yes, but for "conventional" cylinders only
Product Category on PCDB	No
Description of technology function including any limitations *(supplementary schematics or diagrams on separate sheets)*	Cylinder optimised for connection to heat pumps. Increased heat exchange surface area (immersed coil or external plate to plate) optimises thermal transfer for high primary flow/lower primary temperatures produced by heat pumps. Control integration with Heat Pump. Potentially needs additional heat input to raise stored volume to "usable" comfort levels. Possibly needs pasteurisation cycle to raise stored volume to level where bacteria will be "killed".
Relevant BS / EN or other performance standards	Established series of product safety and constructional standards depending on type (e.g. EN 12897, EN 60335-2-21). Performance standards established for the purposes of ErP rating do not cover this mode of operation - only consider "conventional" energy inputs.
Smart Grid / ToU benefit to performance?	Yes. Could be integrated with DSR control technology to either heat using an auxiliary immersion heater or the heat pump.
Modelling Proposals *(supplementary document if needed)*	Not known
Case Study or other supporting data? *(supplementary document if needed)*	Several "Heat Pump" optimised cylinders are already on the market

Technology Type	PV compatible cylinder / PV diverter controls
Methodology Included in SAP 10	Yes, but for "conventional" cylinders only
Product Category on PCDB	No
Description of technology function including any limitations *(supplementary schematics or diagrams on separate sheets)*	Hot water storage cylinder with integrated PV diverter controls (or connected to a separate PV diverter control). When power from local PV panels is being exported and storage cylinder has energy (hot water) capacity the PV energy is diverted to an immersion heater in the cylinder to use the PV generated energy to heat, or pre-heat, the cylinder. Potentially needs additional heat input to raise stored volume to "usable" comfort levels if PV energy is intermittent or only available for a short period. Possibly needs pasteurisation cycle to raise stored volume to level where bacteria will be "killed".
Relevant BS / EN or other performance standards	Established series of product safety and constructional standards depending on type (e.g. EN 12897, EN 60335-2-21). Performance standards established for the purposes of ErP rating do not cover this mode of operation - only consider "conventional" energy inputs.
Smart Grid / ToU benefit to performance?	Yes. Could be integrated with DSR control technology to heat using the immersion heater if insufficient local generation, but energy input is possible to the cylinder.
Modelling Proposals *(supplementary document if needed)*	Assessment required of seasonal local PV generation and proportion available to the cylinder. Calculation required of how much conventional energy input could be replaced by local PV generated energy
Case Study or other supporting data? *(supplementary document if needed)*	A number of these cylinders/devices are available

Technology Type	Heat Pump water heater
Methodology Included in SAP 10	Yes, but for "conventional" cylinders only
Product Category on PCDB	No
Description of technology function including any limitations *(supplementary schematics or diagrams on separate sheets)*	Hot water storage cylinder with integrated dedicated air source heat pump. Requires air to be ducted from outside property (inlet and exhaust). Potentially needs additional heat input to raise stored volume to "usable" comfort levels. Possibly needs pasteurisation cycle to raise stored volume to level where bacteria will be "killed".
Relevant BS / EN or other performance standards	Established product safety, constructional and performance standard EN 16147. Performance standards established for the purposes of ErP rating.
Smart Grid / ToU benefit to performance?	Yes. Could be integrated with DSR control technology to either heat using an auxiliary immersion heater or the heat pump.
Modelling Proposals *(supplementary document if needed)*	Not known
Case Study or other supporting data? *(supplementary document if needed)*	A number Heat Pump Water Heaters operational data should be available - market penetration is much higher in a number of EU countries, notably France and Germany

Technology Type	DHW Thermal Store - Demand Side Response enabled
Methodology Included in SAP 10	Yes, but for "conventional" cylinders only
Product Category on PCDB	No
Description of technology function including any limitations *(supplementary schematics or diagrams on separate sheets)*	As for DHW cylinders but DHW Thermal Store could offer greater energy storage capacity due to higher operating temperatures. Optimised for demand side management - integration with controls and communications technology that allows energy providers to interrogate and access hot water energy storage capacity when there is excess grid generation (usually from renewables input)
Relevant BS / EN or other performance standards	Established series of product safety and constructional standards depending on type (e.g. EN 12897, EN 60335-2-21). Performance standards established for the purposes of ErP rating do not cover this mode of operation - only consider "conventional" energy inputs
Smart Grid / ToU benefit to performance?	Yes. Controls will sense energy capacity of the cylinder and communicate information to energy provider. When excess grid generation is available a communication from the energy provider remotely switches on an immersion heater within the cylinder to heat water using low carbon generated energy
Modelling Proposals *(supplementary document if needed)*	Not known
Case Study or other supporting data? *(supplementary document if needed)*	A number of pilot studies are in operation or development so data should be/become available prior to SAP 11

Technology Type	Hot water cylinder with "Smart" control
Methodology Included in SAP 10	Yes, but for "conventional" cylinders only
Product Category on PCDB	No
Description of technology function including any limitations *(supplementary schematics or diagrams on separate sheets)*	Cylinder incorporates "smart" controls. 'Smart control' is defined by Commission Regulation EU 814/2013 as a "...device that automatically adapts the water heating process to individual usage conditions with the aim of reducing energy consumption…". Within the Regulation it is only applied to directly heated water heaters as the Regulation is assessing energy efficiency at a "product" level only. However, the principles could be applied to indirectly heated cylinders as part of a central heating system. "smart" thermostats are also available which can be retrofitted to an existing cylinder improving the energy efficiency of an existing installation - perhaps a measure that could be recognised in recommendations generated by RdSAP?
Relevant BS / EN or other performance standards	Established series of product safety and constructional standards depending on type (e.g. EN 12897, EN 60335-2-21). Performance standard EN 50440 established for the purposes of ErP rating incorporates a methodology for assessing the efficiency improvement a smart control can provide to a specific water heater when tested to the standardised load profiles as set out in the Regulation. No standardised methodology exists yet to assess the efficiency improvements in an "indirect" system
Smart Grid / ToU benefit to performance?	
Modelling Proposals *(supplementary document if needed)*	Possibly related to assessment methodology contained in EN 50440
Case Study or other supporting data? *(supplementary document if needed)*	Products are already available on the EU market. To qualify as a "smart" control they must meet the efficiency improvement criteria set out in Regulation 814/2013

Technology Type	Hot water cylinder with "Smart" stratification
Methodology Included in SAP 10	Yes, but for "conventional" cylinders only
Product Category on PCDB	No
Description of technology function including any limitations *(supplementary schematics or diagrams on separate sheets)*	Conventional cylinders have a heat input means located in the lower part of the cylinder. When energised entire unheated cylinder volume is heated. With "smart stratification" the heat input is located within the top of the cylinder with cool water forcibly directed to the upper part of the cylinder by pumped circulation. In this way the cylinder heats from the top down and useable volumes of water smaller than the entire capacity can be heated relatively quickly. Sensors can also be placed down the height of the cylinder vessel allowing the amount of hot water to be set to a smaller amount. Could also be integrated with "smart" control to learn and adjust heating patterns to user needs. *See www.mixergy.co.uk for example product details*
Relevant BS / EN or other performance standards	Established series of product safety and constructional standards depending on type (e.g. EN 12897, EN 60335-2-21). No existing performance standard established for this type of water heater although EN 50440 methodology could be applied to directly heated cylinders, including those with "smart" control.
Smart Grid / ToU benefit to performance?	Possibly
Modelling Proposals *(supplementary document if needed)*	Possibly related to assessment methodology contained in EN 50440
Case Study or other supporting data? *(supplementary document if needed)*	Products are already available on the UK market (see Mixergy cylinders[14]) so some operational data should be available from Manufacturer.

[14] https://www.mixergy.co.uk/

Technology Type	Hot water store (either DHW storage or Thermal Store type) with multi heat source input
Methodology Included in SAP 10	Yes, but for "conventional" cylinders only
Product Category on PCDB	No
Description of technology function including any limitations *(supplementary schematics or diagrams on separate sheets)*	Hot water store which can be heated by a number of different heat sources - e.g. solar thermal, heat pump, solar PV, biomass boiler, conventional boiler and immersion heater (or any combination). Allows for energy input from the lowest cost or most eco-friendly heat source whenever available. Allows for the variability of renewable input by being able to be heated by conventional means when alternative technologies cannot meet the hot water demand. Could be controlled by a "smart" energy input control which can assess when certain energy sources are available and/or at the lowest cost and select the "best" heat input source.
Relevant BS / EN or other performance standards	Established series of product safety and constructional standards depending on type (e.g. EN 12897, EN 60335-2-21). Performance standards established for the purposes of ErP rating do not cover multi heat source modes (other than solar thermal backed up by conventional heat sources e.g. boiler or immersion heater)
Smart Grid / ToU benefit to performance?	Yes. A "smart" control system will be able to assess when electricity prices are low due to excess renewable input into the grid and preferentially use this info to either power a heat pump input or immersion heater.
Modelling Proposals *(supplementary document if needed)*	Not known. Will need to be able to model variable heat sources operating at variable times and seasonality.
Case Study or other supporting data? *(supplementary document if needed)*	Several products are already available on the UK market that offer some, or all of, these features so data should be available prior to SAP 11 (although this is likely to be solely manufacturers' data rather than independent studies)

Boilers and zero carbon fuels:

Zero carbon fuels are being developed to replace fossil fuels for current technologies. In 2025 fossil fuels could be excluded from new build properties under current proposals, once zero carbon fuels become available in the market these can become an integral part of the technology solutions.

For gas grids, there is bio-methane injection and hydrogen supported by BEIS as a key technology solution in the move to a zero carbon by 2050.

The HyDeploy[15] project aims to demonstrate that blending hydrogen; of up to 20% with natural gas could be a route to reduce CO_2 emissions in home cooking and heating, without the need to change customer appliances.

The Hy4Heat[16] project is to provide a 100% hydrogen fuel for the UK gas grid. Backed by the wider industry from infrastructure, manufacturers and government and initial findings has shown it is practical feasible potentially of switching from CH_4 to H_2.

In the off-grid sector work is ongoing, OFTEC is developing a road map for 100% bio-oil[17]. Previous work carried to prove a 30% bio fuel mix has taken place with additional field trials planned by OFTEC incorporating the complete supply chain.
Liquid Gas UK[18] advised that bioLPG is available on the market place now[19]. Currently bioLPG cannot be modelled as a fuel choice within SAP, both in new and existing buildings, owing to omission. This barrier to use should be addressed irrespective of the wider work around SAP 11. The CCC have recognised the role bioLPG has to play in decarbonising rural areas, as well as other key voices such as the National Grid ESO; further analysis is available in Liquid Gas UK's technical report on off-grid decarbonisation pathways.[20]
These changes in the fuel supply will result in a reduction of the current intensity values for natural gas and off-grid fuels detailed in table 12 of the SAP specification during the expected lifespan of SAP 11, therefore an essential consideration for modelling of applicable technology groups.

15 https://hydeploy.co.uk/
16 https://www.hy4heat.info/
17 https://www.oftec.org/future-heating
18 https://www.liquidgasuk.org/uploads/DOC5D1B3029E7837.pdf
19 https://www.liquidgasuk.org/uploads/DOC5DA5B52BBA49F.pdf
20 https://www.liquidgasuk.org/uploads/DOC5DA5B347CF3A7.pdf

Flue Gas Heat Recovery (FGHR):
FGHR is currently not represented within the EcoDesign framework but work is underway on EN 13203-7 which will establish an EU wide methodology. Work is currently ongoing within CEN which is expected to deliver outputs after the publication of this report.

Heat Pumps
Feedback from group members suggests that the current SAP methodology and PCDB for this technology group is adequate.

Technology Type	Air Source and Ground Source Heat Pumps
Methodology Included in SAP 10	Yes
Product Category on PCDB	Yes
Description of technology function including any limitations *(supplementary schematics or diagrams on separate sheets)*	Technology already established
Relevant BS / EN or other performance standards	EN 14511 and EN 14825 (used for Ecodesign).
Smart Grid / ToU benefit to performance?	Yes. Particularly, if the fabric of the dwelling is able to keep heat in reasonably well. Heat pumps tend to operate continuously, so it could ramp up at either end of a time period with high prices/low renewable energy output. Hot water production can also be shifted to provide benefits to the network, without inconveniencing the end user (e.g. overnight).
Modelling Proposals *(supplementary document if needed)*	Technology already established
Case Study or other supporting data? *(supplementary document if needed)*	Well researched area. Delta EE produced a specific report on heat pump DSR capacity[21]

[21] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/680512/heat-pumps-smart-grids-roadmap.pdf

Heat Pumps (hybrid)

Smart, grid connected hybrid heat pump systems (comprising a heat pump and boiler in an integrated hydraulic and control configuration) are not currently represented within SAP. It is understood that a BRE project to include such is still ongoing.

The Freedom Project[22] delivered by Western Power Distribution and Wales & West Utilities has shown that heat pumps can take around 80% of heat demand, even in the harder to decarbonise homes, without any changes to the building fabric, pipework or emitters, with decarbonised gas providing the back-up in colder weather, when renewable electricity is low during and when there are electricity grid capacity constraints. The heat pump can be easily retrofitted to an existing gas system.

The UK CCC now favour this technology as needing rapid deployment (10 million by 2032)[23] and all gas distribution and transmission networks are working on a pathway to 2050 with 23 million deployed[24].

Combined Heat and Power (all types, including engine, fuel cell and alternatives)

The group consensus was that current standards cover all known technologies in this area. Notified Bodies now have experience with developing and accepting EC Technical Solutions to cover specific requirements where the technology deviates from what the standards were written to cover.

As part of the Hy4Heat programme[25] there is a category for 'innovative appliances', which includes some development work for this technology group; once complete the outputs of this work will be relevant to the ongoing development of SAP.

There was some discussion around PAS 67 with a recommendation that there should be some industry input to how entry into SAP can be achieved more cost effectively than present for this technology group.

Waste Water Heat Recovery (WWHR)

Technology Type	Waste Water Heat Recovery Systems (WWHRS) attached to Showers
Methodology Included in SAP 10	Yes
Product Category on PCDB	Yes

[22] https://www.wwutilities.co.uk/media/2829/freedom-project-final-report-october-2018.pdf
[23] https://www.theccc.org.uk/publication/hydrogen-in-a-low-carbon-economy/
[24] http://www.energynetworks.org/assets/files/gas/Navigant%20Pathways%20to%20Net-Zero.pdf
[25] https://www.hy4heat.info/

Description of technology function including any limitations *(supplementary schematics or diagrams on separate sheets)*	WWHRS are attached to the shower drain outlet and via a passive heat exchanger extract energy contained within the waste shower water and instantaneously return this to the hot water system by preheating the incoming cold mains water. Three installation methods are recognised in SAP (System A/B/C). System A takes the preheated water to the water heater and the cold side of the shower, System B takes the preheat just to the cold side of the shower and System C takes the preheat just to the water heater. The installation methods will alter the efficiency of the WWHRS, with System A the most efficient followed by C and the A.
Relevant BS / EN or other performance standards	NEN7120+C2/A1:2017 is the test method used at Kiwa Netherland B.V. to assess the efficiency of WWHRS. This has bene the main methodology accepted by BRE for input onto the PCDB. In Europe, many of the WWHRS systems use a double walled heat exchanger to confirm to EN 1717, as waste shower water is graded higher than in the UK. To meet UK water regulations, single walled exchangers can be used but the trap of the shower must be moved downstream of the WWHRS.
Smart Grid / ToU benefit to performance?	No. Not directly, but WWHRS will reduce peak load demands on the grid.
Modelling Proposals *(supplementary document if needed)*	The main calculations for WWHRS are already in SAP. However, certain aspects need to be reviewed. These include: 1. Occupancy rate calculations 2. Shower flow rate – Standard and compliance checking 3. Shower time 4. Standard hot water assumptions See attached report from Currie & Brown for further analysis and information.
Case Study or other supporting data? *(supplementary document if needed)*	BRE have recently stated that they believe new testing is required on overall hot water use, flow temperatures etc., as many of the assumptions/data in SAP are from either field trials or expert assumptions made over 20 years ago. There may be additional data from certain WWHRS projects, but this would be from the Netherlands rather than the UK. Additionally, work could soon start looking at the impact of WWHRS on a complete hot water system rather than just the direct savings made from the heat recovery. E.g. Hot water storage reductions.

Heat Networks and Heat Interface Units (HIU)

During the MEHNA group meeting on the 1st August 2019, members gave input into the SAPIF process, with the following proposals.

- HIU heat loss factor – review of how this will be treated in SAP10.1 regarding the default value. (test standard, different lateral lengths, average of BESA test 4 and double counting with the DLF)
- Connectivity of the HIU – benefits of predictive heat demand for energy centre control (open source protocol)
- Minimum level of VWART for HIU used in future heat networks (assuming BESA test is extended to other HIU types).

Standardisation and methodology in this area for the UK market is progressing rapidly, however a comprehensive assessment is not possible at the time of writing owing to ongoing activity with BSi and other parties.

The HIU heat loss factor, although being dealt with within SAP10.1, should be carried over to SAP11 if a satisfactory outcome is not achieved. The current proposal to use the PCDB for HIU is based on the test data from the BESA HIU test regime. Since this test is currently only available for indirect HIU, there is no level playing field for other HIU types. It is possible by 2025 that other versions of the BESA HIU test regime could exist, since it is the intention of the steering group to do this. However, progress could be technically difficult, and it could be that only the most common varieties of HIU end up with a suitable test.

The default value of 1.46kWh/day is based on the original SBRI funded Fairheat testing, which was the forerunner of the BESA HIU test regime. This had a small sample size and it seems only reasonable that the data now available (from the published test results) would form a better basis for the default. It is believed that this would result in a default nearer 1kWh/day.
There is the possibility for data from the HIU to be used by the heat network operator. There is currently some EU funded research in the form of the THERMOS project, which will investigate this topic, as well as others.

The data from the HIU could help with better predictive heat generation, early identification of problems and improved understanding of diversity for an individual project. All of these benefits can help to refine the efficiency of a heat network, which being a large system, can involve extended commissioning.

If the BESA HIU test regime is extended to other HIU types, it may be valid to have a maximum VWART overall return temperature. CIBSE's revised CP1 has already set a best practise level of 33°C. This could be a natural starting point to drive development of HIU.

The benefit of a lower VWART is to the efficiency of the heat network. Lower return temperatures from the HIU result in lower heat losses. In this way the HIU heat loss factor has some influence on the overall network distribution loss factor.

Solar and Storage for Heat and Hot Water

Key Recommendations:

1. **Combine solar and storage systems into a single SAP Appendix** (combine SAP 10.1 Appendix H and the solar parts of Appendix M/G) since systems in the 2020s will be increasingly hybridised. This means that rooftop solar arrays will generate both heat and power, with the power

component of the solar array output increasingly being used for heating (space heating, hot water, drying and cooking).
2. **A new solar and storage component** which is poorly defined in SAP 10.1, but should be incorporated into SAP 11, is the **Hybrid Solar Panel**. This consists of a single solar panel which combines a solar thermal absorber and photovoltaic cells, to generate both heat and power.

Background to Recommendation 1: The considered use of solar and storage has been central to the design of energy efficient buildings for over 2,500 years (Butti and Perlin, 1981, p. 3) and this is certainly going to continue to be the case in the 2020s. The use of solar and storage in residential building architecture can be broadly categorised into 'passive' and 'active'. For the SAPIF Heat and Hot Water Working Group, only active[26] solar and storage are being considered, with 'active' referring to systems which use equipment to collect, store and distribute solar energy in a controlled manner (Beckman, Klein and Duffie, 1977, p. 1). Active solar and storage products which resemble the products seen on the market today have been around since the 1930s (Denzer, 2013). But over the past 10 years, two major trends have shifted the solar and storage market:

1. There has been a price reduction in solar power panels (solar photovoltaics) and the development of cost-effective residential-scale electrical storage (5 - 15kWh home batteries).
2. There is an increasing electrification of household appliances which use heat, such as dishwashers, dryers, cooking hobs, electric showers, hot water tanks using immersion heaters, instantaneous hot water taps, and heat pumps for space heating and hot water.

These two trends are likely to continue in 2020. This means, firstly, that rooftop solar arrays will increasingly generate both heat and power, and secondly, that the power component of the solar array output will increasingly be used for heating and hot water. For example, a rooftop solar array might have a solar heat component in the form of a hot water storage cylinder with a solar thermal coil (as described in SAP 10.1 Appendix H). The same array might have a solar electrical component used to power an immersion heater installed in the same hot water cylinder, to bring the water to the required temperature or sterilise it (PV diverter, as described in SAP 10.1 Appendix G4).

Given the increasing interconnectedness of solar and storage in 2020, our recommendation is to consider **combining solar and storage systems into a single SAP Appendix.**

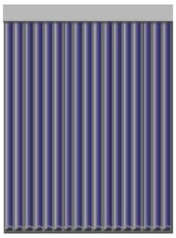
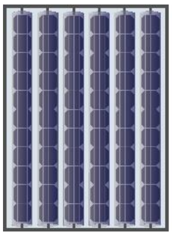
Background to Recommendation 2: Solar and storage components currently included in SAP 10.1 are:

- Solar heat panels and hot water storage for heating and domestic hot water (Appendix H: Solar thermal systems).
- Solar power panels and electrical storage for electricity (Appendix M1: Photovoltaics) and solar power for domestic hot water (Appendix G4: PV diverters).

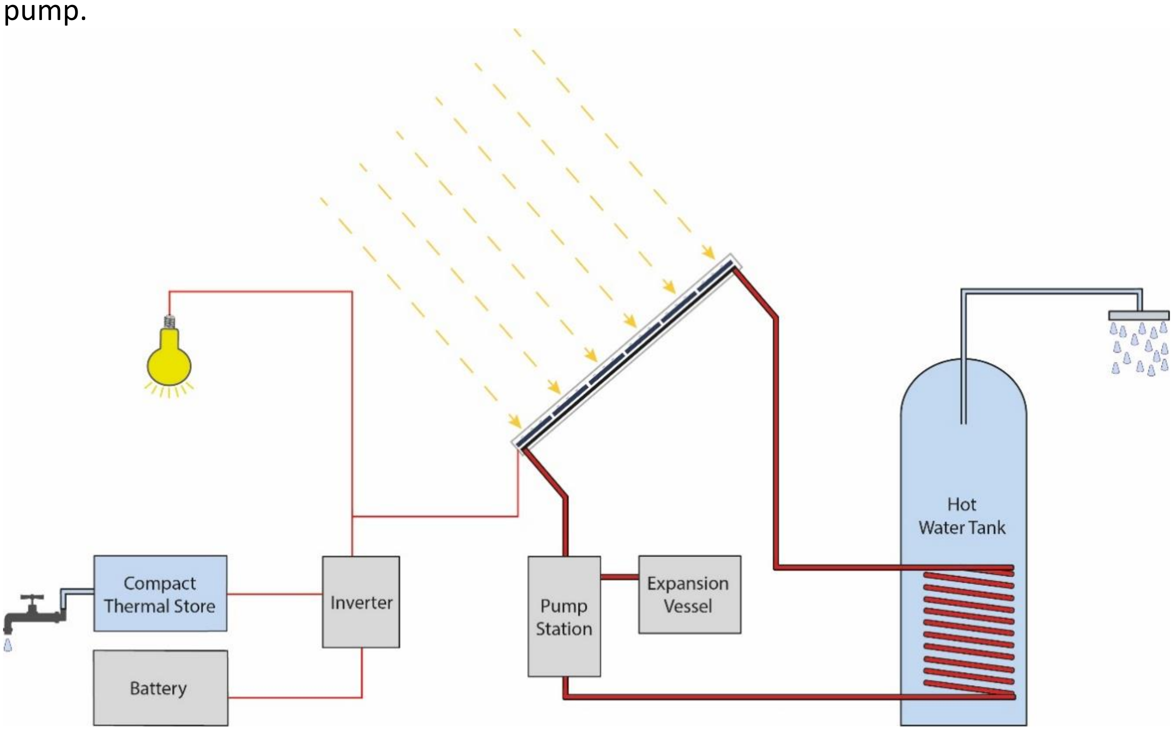
One product seeing significant growth in the solar and storage market (Weiss and Spork-Dur, 2019) that is not currently well defined in SAP 10.1, is the hybrid solar panel which generates both heat and power from the same panel (a solar panel that is simultaneously producing hot water and electricity). The table overleaf illustrates how these hybrid solar panels relate to the solar panels already included in SAP 10.1:

[26] In SAP 10.1, passive solar is dealt with within the main heat loss calculation (Chapter 3 Heat Transmission + Chapter 6 Solar Gains and Utilisation Factor).

Types of solar panels used in UK residential buildings

	Solar Heat Panels (Liquid heat transfer)	**Hydrid Solar Heat and Power Panels** (Liquid heat transfer and electrical energy tranfer)	**Solar Power Panels** (Electrical energy tranfer)
SAP 10.1	Appendix H	Appendix H & M/G	Appendix M/G
Flat Plate Also know as flat-plate collectors			
Evacuated Tube Also known as evacuated tube collectors			No products of this type are available.

The illustrative Figure below shows how these hybrid solar heat and power panels are used to provide heat (hot water, as illustrated, or space heating) and electrical power for lighting and/or appliances. The power could also be used for a compact thermal store or to power the compressor of a heat pump.



The Table below provides further information about hybrid solar panels and the standards and certification that would enable them to be incorporated into SAP 11.

Technology Type	**Hybrid Solar Panels** (also known as PVT)
Methodology Included in SAP 10	No (see clarification in 'Modelling Proposals' below)
Product Category on PCDB	No
Description of technology function including any limitations	A hybrid solar panel generates heat and power from the same solar collection surface (a solar panel simultaneously producing electricity and hot water).
Relevant BS / EN or other performance standards	Solar heat part certified to ISO 9806 and solar power part certified to EN 61215 + EN61730
Smart Grid / ToU benefit to performance?	It is anticipated that most solar inverters and solar pump stations by the mid-2020s will be smart grid enabled.
Modelling Proposals	The existing SAP 10.1 models for solar heat (Appendix H) and solar power (Appendix M/G) could be combined to model heating and hot water systems that use hybrid solar panels.
Case Study or other supporting data?	Over 1 million m^2 of solar PVT now active worldwide: See 2019 edition of the IEA Solar Heating and Cooling TCP publication Solar Heat Worldwide (Weiss and Spork-Dur, 2019). It is one of the fastest growing segments of the solar heat and storage market. Case Study: Naked Energy Virtu PVT on the Swansea University Active Office: • https://www.nakedenergy.co.uk/news/2019/5/17/virtu-part-of-uks-first-energy-positive-office • https://www.nakedenergy.co.uk/news/2020/3/21/case-study-virtu-pvt-active-office-swansea Case Study: All-Electric House by DuelSun & Vaillant (Netherlands) with PVT being used for domestic hot water and supporting a ground source heat pump: • https://dualsun.com/en/realisations/all-electric-house-with-dualsun-panels-berkel-rodenrijs-nl/ Companies active in the UK: • Evacuated Tube Type: virtuPVT by Naked Energy (https://www.nakedenergy.co.uk/) • Flat Plate Type: PowerVolt by SOLiMPEKS (https://www.convertenergy.co.uk/pv-t-hybrid-solar)

References:

Beckman, W. A., Klein, S. A. and Duffie, J. A. (1977) *Solar heating design, by the f-chart method*. New York: Wiley.

Butti, K. and Perlin, J. (1981) *A golden thread: 2500 years of solar architecture and technology*. London: Boyars.
Denzer, A. (2013) *The solar house: pioneering sustainable design*. New York: Rizzoli.
Weiss, W. and Spork-Dur, M. (2019) *Solar Heat Worldwide: 2019 Edition*. IEA Solar Heating and Cooling (SHC) Programme. Available at: https://www.iea-shc.org/Data/Sites/1/publications/Solar-Heat-Worldwide-2019.pdf (Accessed: 22 June 2019).

Instantaneous Point of Use Water Heaters (single and multipoint)

Technology Type	Instantaneous Water Heaters
Methodology Included in SAP 10.0?	Yes
Product Category on PCDB?	No
Description of technology function including any limitations *(supplementary schematics or diagrams on separate sheets)*	Instantaneous water heaters are often connected to the output of a combination boiler and will vary their output depending on the incoming flow temperature. This is done to avoid the lag in receiving hot water e.g. in an upstairs bathroom in a large property.
Relevant BS / EN or other performance standards	EN 60335-1, EN 60335-2-35
Smart Grid / ToU benefit to performance?	Limited potential due to its instantaneous nature of their usage. Combination with PV or solar thermal could deliver flexibility benefits. Instantaneous water heaters are sometimes connected with load shifting relays, so that other electric appliances are turned off if there is demand for hot water.
Modelling Proposals *(supplementary document if needed)*	The current methodology assumes peak electricity consumption for the entire duration of the shower. This is incorrect as the output will fluctuate during a shower. In addition, the incoming temperature will vary throughout the year and this is not recognised for electric showers (it is for other types of showers). In addition, the current SAP methodology does not recognise the fact that electric showers will save water compared to a stored water system.
Case Study or other supporting data? *(supplementary document if needed)*	Monitoring data of electrically heated dwellings (student accommodation) will be used to attempt to determine actual electricity use and compare it with SAP's calculated electricity consumption.

Technology Type	Electric Showers
Methodology Included in SAP 10.0?	Yes
Product Category on PCDB?	No
Description of technology function including any limitations *(supplementary schematics or diagrams on separate sheets)*	Electric showers are directly connected to the mains and have their own dedicated fuse. Electric showers are the easiest showers to install in terms of compatibility with existing water heating systems and locations throughout the home. They draw water direct from the mains water supply and heat it as it is used for showering.
Relevant BS / EN or other performance standards	EN 60335-1, EN60335-2-35, EN 60335-2-41 (Pumped showers), EN 300 328, EN 301 489-1, EN 301 489-17, EN 62233-2, EN62479, BS6920, WRAS, EN50193-1
Smart Grid / ToU benefit to performance?	Limited potential due to its instantaneous nature of their usage. Combination with PV or solar thermal could deliver flexibility benefits.
Modelling Proposals *(supplementary document if needed)*	The current methodology assumes peak electricity consumption for the entire duration of the shower. This is incorrect as the output will fluctuate during a shower. In addition, the incoming temperature will vary throughout the year and this is not recognised for electric showers (it is for other types of showers). In addition, the current SAP methodology does not recognise the fact that electric showers will save water compared to a stored water system.
Case Study or other supporting data? *(supplementary document if needed)*	The current methodology assumes peak electricity consumption for the entire durations of the shower. This is incorrect as the output will fluctuate during a shower. In addition, the incoming temperature will vary throughout the year and this is not recognised for electric showers (it is for other types of showers). In addition, the current SAP methodology does not recognise the fact that electric showers will save water compared to a stored water system

High Efficiency Showers and Outlets

Separate from the production of hot water there are developments ongoing related to reducing hot water demand through outlet design.

Kelda Technology[27] has created an air-powered water saving shower using 'water-in-air' technology, independently proven to significantly reduce water consumption, energy consumption and carbon emissions - without compromising shower experience. The design incorporates an intelligent control hub and fan that controls and propels the optimum flow of water and air to the shower head. Water is injected into the air and accelerated out of a jet-type nozzle, creating a spray (with perfect droplet size) that uses 50% less water but feels more powerful.

Case Study – GLL Windrush Leisure Centre

In a recent case study working with the biggest leisure provider in the UK (GLL - Greenwich Leisure Limited) Kelda helped deliver water and water heating savings of over 40% while improving member experience by 160%.
A typical shower in a commercial environment will generally operate at a flow rate in excess of 9 litres per minute. A Kelda Technology Shower System can offer an invigorating shower experience with flow rates from as low as 4.0 (5.0 or 6.0) litres per minute, equivalent to a spray force of 8.0 (10.0 or 12.0) litres per minute – meaning no loss in spray force.

The Kelda installation at GLL Windrush Leisure Centre provided water and water heating savings of 42%. The total water usage dropped by 3,364 litres per day, equating to an annual saving of 1,217,652 litres per year.

[27] https://keldatechnology.com/

Appendix 2 – Working Group Members

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Alpha Heating	Darran Smith
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Ariston	Derek Warren, Steve Long
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Beama	Adrian Regueria-Lopez
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Glen Dimplex	Tim Altham
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HHIC	Steve Sutton, Stewart Clements
HWA	Martyn Griffiths, Alan Clarke
ICOM	Ross Anderson
Ideal Boilers	Andrew Keyworth, Richard Farrow
Kelda Technology	Paul Ravnbo West
Kingspan	Andrew Ogden
MEHNA	Pete Mills
Mixergy	Peter Armstrong
Recoup Energy	Ian Steward, Kieron Dudley, Ellis Maginn
Sav Systems	Beata Blachut, Silas Flytkjaer
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- End of Appendix 8a -

Appendix 8b

WG2 – Smart Controls, Technologies and Tariffs

Executive Summary

This report is from one of five working groups set up on behalf of the SAP Industry Forum (SAPIF) to look at the incorporation of technologies that will be mainstream in the mid-2020s into a future version of the SAP energy calculation methodology, likely to be called SAP 11.

The main conclusions and recommendations from the group are listed below and detailed in the rest of the report:

- The incorporation of these technologies into SAP will be challenging for several reasons. In particular, there is a need for SAP to be more dynamic in dealing with these technologies as its current approach is unsuitable.
- Smart controls used as a replacement for a programmable room thermostat (or programmer and room thermostat) are a widely available technology which is evolving quickly and there is significantly robust evidence of its impact on energy use.
- Using the available evidence, a single energy saving could be applied to a wide range of 'smart thermostats' that meet the generic definition, applied as either reduced heating operating times or reduced average dwelling temperature. As most of these devices would be connected there is the potential for manufactures to submit real life performance data.
- There are a wide range of additional smart controls that need to be evaluated, particularly zoned smart control and automatic shading.
- The group has identified a number of domestic smart flexible technologies that are either available or likely to be available on a domestic level in the mid-2020's. Calculation of savings would only be possible in conjunction with a model of a smart tariff.
- Recognising the nascent stage of both the UK flexibility services market and necessary smart flexible technology market, various actions are recommended to prepare a standard assessment procedure in anticipation for the roll-out of this technology within the UK.
- Incorporation of smart tariffs for new homes in SAP 11 could validate the savings potential for smart ready buildings. In terms of both cost and carbon, based on the level of flexibility available to the building. This could potentially be based on a 5 year forward looking dynamic tariff modelled on costs and carbon.

Background

This report has been produced by a working group set up on behalf of the SAP Industry Forum (SAPIF)[28] to look at the incorporation of future technologies for homes within the SAP (Standard Assessment Procedure (SAP) energy calculation methodology – intended to be called 'SAP 11' and due for release in 2025. The contents cover work carried out from February 2019 to February 2020. A list of participants in the working group and the organisations they represent can be found in Appendix A.

Scope of group

The defined scope was to cover smart controls, technologies and tariffs. The group recognised that, in the context of SAP, the key focus was to look at control technologies for heating and hot water systems but that the latter was also being considered by a separate SAP 11 working group on hot water. In addition, SAP is currently limited in its ability to assess the benefits offered by connected homes technology or technologies in homes that facilitate grid flexibility[29]. On this basis, the group determined that its focus would be:

1. Smart controls for heating systems (recognising the overlap with the working group on hot water), including smart control of dynamic solar shading
2. Demand Side Response (DSR) technologies offering grid flexibility.
3. Flexible tariffs that could work in conjunction with DSR technologies to deliver energy cost and/or carbon savings

Initial analysis

The group recognised that the incorporation of these technologies into SAP will be challenging for several reasons, which are outlined below:

- While there are a large range of technologies that can be described as 'smart', the amount of evidence available to support the addition of a new technology into SAP under current processes (generally requiring large scale field trials) is currently limited compared to what would normally be expected. Largely this is because many of these technologies are relatively new to the market, but also because the technologies can be very diverse in operation and therefore large-scale analysis can be challenging. There will also need to be consideration of the processes to allow emerging 'smart' technologies to be incorporated into SAP (e.g. through Appendix Q.)
- The fact that smart technologies generally provide the ability for better user interaction with building system controls, or modify the effects of behaviour on energy usage, means that they are typically difficult to account for in a calculation methodology such as SAP which is intended to be a comparison tool independent of occupant behaviour. This is a general issue with the technologies we are dealing with. Currently, SAP does not explicitly consider behavioural affect, for example the addition of a heating programmer in SAP does not change assumptions on heating operating periods.
- Significant changes are needed in SAP to deal with technologies for connected homes or offering grid flexibility. The smart technologies considered by this working group can deliver outcomes, in terms of comfort, cost and carbon by combining (1) the capabilities of building technologies present, (2) the needs and behaviour of the occupants, and (3) the price and carbon content of various energy sources

[28] https://www.bregroup.com/sap/sap-industry-forum/

[29] The working group was instructed that electric vehicle infrastructure in homes was to be specifically excluded. However, the group notes that electric vehicles charging, and the potential use of such vehicles as mobile batteries, would be a significant element of grid flexibility within a home and therefore its inclusion in future versions of SAP is strongly recommended. Electric vehicles are also significant component of a home's electricity consumption and therefore should be seen as part of the home from the perspective of SAP.

at different times. In particular, there is a need for SAP to be more dynamic in dealing with these technologies as its current approach is unsuitable. This might necessitate a completely new version of SAP, a 'dynamic' add on to the existing methodology, or a separate tool focussing on the dynamic elements.

- The scope of SAP currently excludes the energy use of home appliances given that it seeks to compare buildings independent of occupants, and choices of appliances will be made by those occupants. This is problematic for the technologies covered by this report as appliances chosen by occupants could well incorporate DSR functionality, and the choice of smart tariffs will also usually be at the discretion of the occupants. Even smart controls could be transferable because of emerging supply chains and high value of certain technologies. Consideration needs to be given to how SAP might deal with these issues – one potential solution could be an additional layer to a SAP calculation that accommodates user choice and behaviour, similar to the behavioural calculation element introduced for the Green Deal.

With respect to the terms of reference, the working group considered the technologies in terms of how they might be assessed in the future which was assumed could be through:

- Using a SAP model similar to SAP 10.
- Using a newly developed calculation tool or a separate module that would be linked to, or sit alongside, SAP.
- Using some other methodology for new build compliance (e.g. a pass/fail list depending on technologies present.
- A stripped-down version of SAP (or another tool) for Energy Performance Certificates.

While the conclusions are not specifically built around these options they should be borne in mind as possible mechanisms.

Evidence base for a carbon energy focussed approach

The NIA funded Freedom project was a cross-sector collaboration lead PassivSystems for electricity and gas distribution networks Western Power Distribution and Wales & West Utilities and supported by Imperial College, Delta-ee and City University.

The project ran overwinter 2017-2018 and utilised 75 trial homes installed with hybrid heating systems consisting of a gas boiler combined with an air source heat pump. The performance of hybrid heating systems was investigated under a number of different control scenarios. Throughout the trial, the operation was optimised to achieve comfort levels for minimum running costs with the needs of the householder prioritised. These experiments were highly innovative as live, real-wold forecasts were used to influence heating system operation.

Electricity pricing from live day-ahead auctions was used, simulating a scenario where the user is directly charged time-varying market prices. Pricing was also applied that directly reflected carbon intensity, using live carbon forecasts from the National Grid for electricity, and also pricing gas by carbon: so that system operation would be optimised for total minimum carbon emissions. At today's carbon factors it was shown that the heat pump is hugely prioritised over the boiler. In future scenarios where renewable gas, such as hydrogen is introduced to the grid, the system switch to gas to reduce carbon emissions. A similar trend was observed when the "marginal" carbon intensity of electricity being pushed to coal generation is considered.

The current SAP approach to modelling heating systems is based simply on heat output and does not consider the incorporation of a switching regime that can account for carbon intensity or price. The smart control systems deployed in the Freedom project demonstrated the capabilities of responding to dynamic fuel prices, emission factors and primary energy factors. The current static SAP model does not account for variability in grid flexibility constraints, fuel prices, carbon emission factors and primary energy factors. With the introduction of variable tariffs such as Octopus Agile or Tide, an increasing number of smart heating control providers are already offering dynamic controls for heat pumps. Moreover, the variability of the carbon intensity of electricity is set to increase dramatically with the penetration of renewable generation such as wind and solar. Controls that can dynamically respond to these will have a significant impact on the actual carbon emissions consumed at a household level.

The key flexibility offered by a smart hybrid heating system is the ability to turn off electricity consumption immediately and indefinitely, without impact on householders as heating can be provided by the gas boiler instead. Large scale field trials are now underway to demonstrate this technology through the BEIS funded No Regrets project with EDF. This will trial deploy over 1000 grid-enabled smart hybrid installations.

https://www.westernpower.co.uk/projects/freedom

https://www.westernpower.co.uk/downloads/12221

1. Smart controls

As mentioned above, the working group focussed on smart controls for heating systems. There is a wide range of technologies that fall into this category and we have attempted to list all the possible technologies in section 1.4. However, the working group sees that the main case for inclusion at the current time would be the central smart thermostat, covered in section 1.1. below.

1.1 Central smart thermostat

The group considers that the primary technology for consideration would be smart controls used as a replacement for a programmable room thermostat (or programmer and room thermostat.) This classification of control is a widely available technology which is evolving quickly and there is significantly robust evidence of its impact on energy use. The following classifies the technology and its observed evolution:

Asset Type	**Characteristics**	
Control	Centralised	Distributed
Sensor	Centralised	Room by Room
Typical heat source	Centralised, Slow and Continuous	Room by Room / Rapid response

The above table provides a simplified view on the evolution of smart controls. The characteristics are not intended to reflect improvements in efficiency but only to describe evolving approaches in addressing the question of efficient heat.

Smart controls initially evolved from the programmable thermostat, replacing it with a device that controls heating assets using data from a variety of sensors, user actions and external data sources. These same smart controls are now evolving to become more granular in nature and enable a more targeted heat strategy.

Both centralised and distributed approaches provide the potential for significant efficiency improvements over traditional approaches, but each has the potential to provide even greater efficiency in specific use scenarios. Differences in occupancy is likely to be the most significant factor with regards to these greater efficiencies, the greater the occupancy the greater the efficiency of continuous heat.

1.1.1 Definition

In generic terms this is a sensing and learning device that automatically matches the operation of the heating system to the needs and behaviour of the occupants. This technology is expected to compensate for the fact that many householders don't adjust the operational settings on their programmer.

As a central programmer/thermostat its control impact would be limited to the operation of the heat source (rather than individual rooms) and this operation is assumed to be on/off.

1.1.2 Evidence base

The main source of evidence provided to the group was a study by the Behavioural Insights Team on the Google Nest thermostat[30]. Their proposition is that smart heating controls employing sensors and learning algorithms may provide a solution to consumers failing to set the most efficient schedules on their heating controls.

The main study is a randomised control trial from 2016/17 comparing 139 houses randomly allocated a Nest Learning Thermostat with a control group of 139 who didn't. All homes had a programmer, thermostat and TRVs to begin with.

The research showed a winter household gas saving of 5.6%, which was estimated to mean a heating system saving of 6.7%.

[30] https://www.bi.team/publications/evaluating-the-nest-learning-thermostat/

This research is the best evidence for the savings potential from smart controls. The main limitation is that we cannot be sure what element(s) of the smart thermostat functionality deliver the savings effect.

Additional submissions from Climate and Green Energy Options on data from installed smart thermostats showed reductions in operating times compared to the SAP profile, which itself is derived from the Energy Follow Up Survey[31] to the English Housing Survey. Hence, this provides a reasonable level of confidence that smart thermostats in general reduce operating times of heating systems and this is therefore likely to be a primary factor in the savings recorded in the Nest trials.

The approach of carrying out costly and lengthy lab and field testing of state-of-the-art technology is in itself a barrier to innovation and quick uptake, therefore the role of computer modelling and simulation presents a lower cost method for validation. Strathclyde University have previously done such work and it would be worthwhile following up. A digital twin of a physical 'test house' could be modelled and the simulation validated against the real-world version. The different types of technologies could then be simulated with a high degree of confidence in the test results.

1.1.3 Proposed application within SAP

Based on the available evidence, a single energy saving could be applied to a wide range of 'smart thermostats' that meet the generic definition. This could be applied within the current SAP methodology as either[32]:

- A reduction in the assumed operating times of the main heating appliance
- A reduced average temperature in the dwelling over a 24-hour period

As most of these devices would be connected there is the potential for manufacturers to submit real life data on the performance of their devices in-situ. This would require manufacturers to agree to provide data to a gatekeeper (e.g. BRE) to allow for verification. The data could serve either as a qualifying factor for the device to be credited within SAP, or to allow differentiation in savings scores for specific devices.

Such an approach is used within the Energy Star system in the US, where data from connected thermostats is utilised to affirm specification compliance, develop a performance metric, and assess energy savings potential in the future[33].

1.2 Zoned (room by room) smart control

There are also a growing number of smart control technologies that provide similar benefits but on a room by room basis. Theoretically this approach could provide greater savings than a centralised smart thermostat but, currently, there is less evidence on the performance of such systems.

Zonal heating control of domestic homes can yield very significant energy savings in a range of applications. This type of multi-zoning technology that enables adjustment of temperature setpoint in different rooms or zones has been proven to deliver reductions in fuel consumption over and above heating systems controlled by a single room thermostat for the whole house. The technology is already recognised and categorised in ErP ratings (Class VIII definition) and within SAP (Communicating TRV[34]), so is established with quantified benefits.

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[31] https://www.gov.uk/government/statistics/energy-follow-up-survey-efus-2011

[32] A further metric could be available for heating controls that can respond to price signals or carbon signals to control hybrid or multivalent heating systems, but further work will be needed on this. Research on simulating such systems is available at: http://www.naun.org/main/NAUN/energyenvironment/17-106.pdf

[33] https://www.energystar.gov/products/spec/smart_home_energy_management_systems_pdf

[34] 9.4.8 Communicating TRV - A TRV that has the capability to respond to commands (relating to both timing and temperature level) from a central controller. Note. Systems of communicating TRVs recognised in SAP are included in the Products Characteristics Database and incorporate provision for boiler interlock for space heating (see 9.4.11).

Communicating TRVs have been researched at Loughborough University[35] and practical experiments have supported the double-digit reductions in fuel consumption that are reported in typical customer installations.

These savings are independent of being connected to internet/cloud/smart home. It is however envisaged that further savings can be achieved by automating the 'standby' of the heating either by manual remote override or geolocation/behavioural automation.

1.3 Automatic shading

Automatic shading has been included within the report of the SAP 11 WG looking at overheating but can also be considered in the context of smart temperature control so is also referenced here.

Innovations in shading systems now provide the opportunity to either control shading devices with the use of motorised systems and automate opening and closures of shading systems based on external climate data (BRE, 2017). The former has been evidenced to increase the frequency of blind opening and closures (Paule et al., 2015). Whilst motorised shading devices are frequently found in domestic homes automated shading systems are only found in commercial properties and are only featured in 'smart' homes such as the Velux Model Homes (Foldbjerg et al., 2020).

These innovations in technology are supported by the Energy Performance Building Directive Recast (2018), which has been furthered by the proposal of a Smart Readiness Indicator (SRI) (BPIE, 2019). The curation of the SRI has led to the development of EN ISO 52016 (BSI, 2017), which addresses automated facades. The reasoning for the inclusion of shading in the SRI is that it is already well established that a dynamic façade will improve energy consumption and the comfort of occupants. This will be further improved if shading devices operate when occupants are not able to open and close their blinds when they are not occupied.

A study carried out by ES-SO (European Solar Shading Organisation) identified that through using the Energy Balance Methodology shading can provide 22% energy savings and reduce CO_2 emissions by 137.52 Mt/yr across the EU (ES-SO, 2018; Hutchins, 2015).

The British Blind and Shutter Association (BBSA) commissioned the National Energy Foundation (NEF) to perform an evidence-based investigation into the current and potential impact of solar shading in the UK built environment.[36]

Further studies that feature the energy savings of shading are referenced within the SAP Group #4 Overheating submission.

Incorporation of automation and user control strategies for shading is a complex technology to incorporate in SAP however the business case for improved energy efficiency is proven and the benefit can only be realised through thermally dynamic building modelling and climate data as opposed to the current simplified calculation methodology in SAP and the averaged weather datasets used. Further evidence relating to the control of shading devices are referenced within the SAP Group #4 Overheating submission.

1.4 Other smart control technologies

The working group has also defined a wider list of smart control technologies that we expect to be widely available by the mid-2020s. These are below:

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35 https://repository.lboro.ac.uk/articles/Measuring_the_potential_of_zonal_space_heating_controls_to_reduce_energy_use_in_UK_homes_The_case_of_un-furbished_1930s_dwellings_-_dataset/8677766

36 http://www.nef.org.uk/themes/site_themes/agile_records/images/uploads/BBSA-NEF-Solar-Shading-Impact-Report-June-2016.pdf

	Categories of control/optimisation/visualisation	Technologies included	Impact on standard SAP profile/assumptions
1	Automatically change duration of heating	Occupancy detection, remote control (automatic), learning of occupancy patterns	Reduce time where people leave the dwelling during the schedule, or don't return during schedule.
2	Manually change duration of heating from outside the dwelling	Remote control (manual app)	Occupants can defer heating operation when not coming home
3	Apply setback temperatures for part of the 'on' period	Programmable thermostat, occupancy detection, remote control (automatic), remote control (manual)	Reduce internal temperature for part of occupancy
4	Automatically change duration of heating for individual rooms	Occupancy detection + room temperature control	Reduce proportion of house heated leading to lower average temperature
5	Automatically apply setback temperatures for individual rooms while heating is on	Occupancy detection + room temperature control	Reduce average temperature
6	Set time and temperature profiles for individual rooms based on non-standard profiles, e.g. home working	Room temperature control + central program control	Change profiles for occupancies
7	Change hot water storage by learning usage patterns	Learning of usage patterns	Reduces overall hot water production/storage based on expected demand and price-based signals or renewable availability
8	Change hot water storage from occupancy detection	Occupancy detection	Limit hot water storage after multiple days of no occupancy
9	Change the amount of energy used at particular times based on carbon intensity (current)	Knowledge of current carbon intensity of energy supply	Reduce carbon intensity, possibility at the expense of greater energy use, based on flexible tariff/grid carbon API
10	Change the amount of energy used at particular times based on carbon intensity (current and future)	Knowledge of current and future carbon intensity of energy supply. Knowledge of future availability of renewable energy sources.	Reduce carbon intensity, possibility at the expense of greater energy use, based on flexible tariff/grid carbon API + predicted use of renewables
11	Change operating time based on carbon intensity (current)	Knowledge of current carbon intensity of energy supply	Defer operation based on flexible tariff/grid API
12	Change operating time based on carbon intensity (current and future)	Knowledge of current and future carbon intensity of energy supply. Knowledge of future availability of renewable energy sources. Learnt heating and hot water requirements.	Defer operation based on flexible tariff/grid API + learnt heating/hot water needs + potential thermal storage + predicted use of renewables

13	Change the amount of energy used at particular times based on energy cost (current)	Knowledge of current unit price of energy supply	Reduce energy used, based on flexible tariff cost
14	Change the amount of energy used at particular times based on energy cost (current and future)	Knowledge of current and future unit price of energy supply. Knowledge of future availability of renewable energy sources. Learnt heating and hot water requirements.	Reduce energy used, based on flexible tariff/ + predicted use of renewables + learnt heating/hot water needs
15	Change operating time based on energy cost (current)	Knowledge of current unit price of energy supply	Defer operation based on flexible tariff
16	Change operating time based on energy cost (current and future)	Knowledge of current and future unit price of energy supply. Knowledge of future availability of renewable energy sources. Learnt heating and hot water requirements.	Defer operation based on flexible tariff + learnt heating/hot water needs + potential thermal storage + renewables
17	Controls to integrate energy use with thermal storage to optimise carbon intensity of energy used in the building		Provides more flexibility for offsetting heating/hot water load (might increase energy use but lower carbon and cost)
18	Controls to integrate energy use with electrical storage to optimise carbon intensity of energy used in the building		Provides more flexibility for offsetting heating/hot water load + MVHR + appliances + EV (might increase energy use but lower carbon and cost)
19	Financial prompts for users to alter behaviour/settings		Tariff or control signals for customers to move operation of appliance to times of lower carbon intensity
20	Control/device prompts users to alter behaviour/settings		Reduce time or temperature of operation or energy use through automatic prompts indicating where usage is excessive or behaviour could be more environmentally friendly
21	Automatic reduction of settings		Automatically reduces time or temperature settings which users can reset if needed/noticed
22	Maintenance prompts from control/device		Informing user or installer of sub-optimal performance of appliances or changes in physical conditions or performance of building.

In addition, industry workshops in 2017 and 2018, co-ordinated by BEAMA and HHIC, established a set of functional definitions for controls that can serve as 'building blocks', wherein a policy definition will always be made up of a combination of these. Within these are a number of functions designated as 'smart', which need to be considered in the context of this work. These are shown below:

Optimisation	
Function name	**Description**
Learning (occupancy)	Monitors occupancy and/or usage patterns and, in response, adjusts system operation to optimise performance, based on cost and/or environmental factors
Learning (performance)	Monitors building or system performance and, in response, adjusts system operation to optimise performance, based on cost and/or environmental factors
Heat source selection	Prioritises between different heat sources, or a combination of these, based on cost and/or environmental factors
Response to external signals	Control with consideration for external signals (e.g. electricity tariff, gas pricing, load shedding signal etc.)
Thermal storage	Prioritises between space and/or water heating and provision/use of thermal storage
Connectivity	
Internet connectivity	Device can connect to the internet
CAD connectivity	Device can be connected to a UK specified Consumer Access Device
Device connectivity	Device can communicate internally and externally to other devices via a communication protocol
User interface	
Consumption feedback	Provides user with feedback on the energy consumption resulting from the operation of the heating or hot water system
Remote access	Facility for system operational parameters to be set and adjusted without physical access to the control interface
Synchronisation	User settings can be synchronised from or with an external device
Safety and security	
Boiler diagnostics	Automatically senses operating parameters of boiler and sends signal to indicate operational issues or efficiency reductions

With the learnings from heating and shading controls, where smart controls have assumed the role of intervention in system control to ensure that most benefit is extracted, there are other areas in the future where this will apply. Smart controls that operate windows and doors based on temperature, air quality and humidity are already emerging.

1.5 Other factors of relevance for assessing smart controls

1.5.1 Applications for low temperature systems

The current SAP approach is to look at a heating operation period of 2 hours in the morning and 7 hours in the afternoon/evening. This is based on EFUS research of actual housing but represents the situation where most homes are heated by high temperature heating systems comprising a boiler and radiators.

The current Future Homes Standard consultation proposes that new homes will have low temperature heating systems from 2020 and therefore different operating times are needed, as would be the case currently with underfloor heating and/or heat pump systems. This will also have an impact on the savings potential of different control strategies.

There will also be a need to consider hot water priority, and the impacts of the fact that low temperature systems need to be combined with hot water cylinders at higher temperatures (and that stored hot water needs to reach minimum temperatures to protect against legionella).

While outside the scope of this working group this is something that must be addressed for SAP 11. It would need to be considered in relation to use of data from smart controls described in 1.1.3 as otherwise the savings could appear to be less if only operating hours were looked at when a smart thermostat is used in a dwelling with low temperature heating.

1.5.2 Automatic balancing controls

While not commonly thought to fall under the heading of 'smart controls' there is significant potential for energy savings from automatic balancing controls that are not currently captured within SAP. With the drive to improve compliance with the Building Regulations following the Hackitt Report the balancing of heating systems should become more prevalent and automatic balancing controls better recognised as a practical technology for dwellings from the 2020 regulations onwards. There is significant evidence on the benefits of balancing itself, indicating from field studies a potential energy saving of 8.8%[37] and other studies indicating this could be even higher when considering the oversizing of pumps to compensate for poorly balanced systems[38].

Long term field research has shown the benefits of automatic balancing controls (in the form of Differential Pressure Control Valves and Pressure Independent Control Valves[39] and it would therefore make sense for these to be considered for SAP 11.

1.5.3 Effect of Control Accuracy

Control Accuracy is a means to describe the performance of a heating control in terms of its ability to maintain temperature in a zone and thereby reduce energy use. Control accuracy has been used for many years in the French RT2012 and RT2020 new-build regulations (known by Certita as Variation Temporal) for TRVs and thermostats. More recently the EN215 standard for TRVs has been updated to include a declaration of Control Accuracy, providing an accredited third-party certification scheme for TRVs. Therefore, we expect that by the mid-2020s the control accuracy of a heating control will be commonly declared and possibly also used in Building Regulations to define better performing controls.

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37 https://www.researchgate.net/publication/318279203_Actual_energy_savings_from_the_use_of_thermostatic_radiator_valves_in_residential_buildings_-_Long_term_field_evaluation

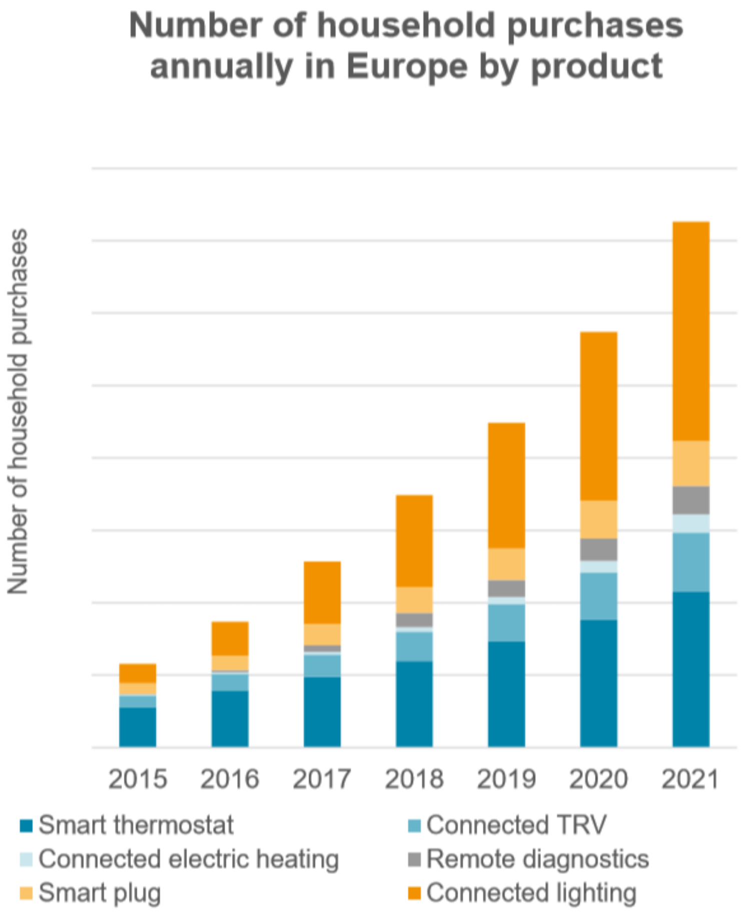
38 https://arrow.tudublin.ie/cgi/viewcontent.cgi?referer=&httpsredir=1&article=1053&context=engschcivart

39 https://www.sciencedirect.com/science/article/abs/pii/S0378778817337842

Although based on European Standards there is little evidence from field testing on the real effect of improved control accuracy on actual energy usage.

1.6 Market intelligence – Predicted Technology Deployment in the 2020s

The working group has not been able to identify sources of robust, publicly available data on predicted deployment in the 2020s, although the graph below, reproduced with kind permission of Delta E-E[40] does indicate the predicted growth of smart thermostats and associated technologies into the 2020s. Given that smart controls can be classed as being relatively mainstream in the UK now that they are incorporated into Part L of the Building Regulations (through the 2018 'boiler plus' amendments) these can be assumed to be a significant technology for the future.



2. Smart Technologies

For this category, the working group has focused on the variety of smart technologies that can adjust consumption (or generation) of energy assets to work in synergy with the wider energy system. Mechanisms such as domestic Demand Side Response (DSR), Time of Use Tariffs (for import and export), Fast Frequency Response and a variety of other mechanisms can offer flexibility to the electricity network. In this context smart flexible technologies are those that can adjust their demand in response to an external grid or pricing signal.

[40] https://www.delta-ee.com/

Rationale for applicability within SAP

Recognising SAP is currently evaluated based on Total Energy Cost, Primary Energy and CO_2 emissions, smart technologies, delivering flexibility, that are linked to smart tariffs (e.g. half-hourly based variable tariffs) stand to save energy cost and reduce carbon emissions. Further utilising property solar generation should be awarded a preferential Primary Energy Factor to differentiate from grid sourced electricity, proportionate to the evidence produced.

It is recognised that in the mid-2020's there will be a growing number of domestic flexibility marketplaces, particularly emerging in places of high grid constraint. In these locations, with the forecasted uptakes for electric vehicle charging and electrification of heat, in addition to continued roof-top solar deployment, the need for domestic flexibility will increase.

To that end, smart technologies that offer this domestic flexibility will enable increased penetration and utilisation of low carbon power generating sources. To date, there is limited evidence in the UK of effective domestic flexibility as we await the emergence of more domestic flexibility marketplaces. That said, the government's (BEIS's) domestic flexibility projects are underway assessing the potential benefits.

Categories of technologies

Lower carbon energy utilisation will be achieved by smart technologies that are automatically able to:

- Reduce their demand during high-carbon times of day
- Defer their demand to low-carbon times of day
- Responsibly increase their demand to absorb excess renewable generation
- Deliver renewable power to the grid during peak demand times
- Provide associated cost signals to householders to encourage low carbon usage

In the US, the EPA's EnergyStar highlight Demand Response (flexibility) to be:

"Changes in electric usage by demand-side resources from their normal consumption patterns in response to changes in the price of electricity over time, or to event signals designed to induce lower electricity demand at times of high wholesale market prices or when system reliability is jeopardized."[41]

In the current evolving markets, external grid signals can be:

- Locally-physically sensed, direct response – i.e. the technology is connected to a physical sensor that is monitoring a physical trace, such as grid frequency, and automatically responding when responding thresholds are passed.
- Digitally signalled, direct response – i.e. a cloud API or smart meter radio signal that appliances / control systems directly respond in an agreed manner, such as the DCC sending an 'OFF' command through the smart meter which smart EV chargers pick up and directly switch off.
- Digitally informed, inferred response – i.e. a tariff signal that is interpreted and appropriate response inferred, such as a half-hourly tariff high price period input driving an EV charger optimiser to defer charging until the lower cost half-hourly periods.

Technologies that do any of the above functions but require manual intervention are valuable but are not considered within scope of a current SAP-like assessment as they are behavioural dependent and therefore unsuitable for a standardised assessment process. However, it could be that wide-scale field trials would show a consistent benefit from behavioural savings for inclusion in SAP, but such evidence is not known to be currently available.

[41] https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20SHEMS%20Version%201.0%20Program%20Requirements.pdf

Technologies identified

The working group has identified a number of domestic smart flexible technologies that are either available or likely to be available on a domestic level in the mid-2020's. It also recognises the SRI and the mechanism being proposed there with broad support [Appendix B].

Useful technologies

The most useful technologies are those with:

- the shortest response time,
- the largest response power,
- that can be held for the longest duration, and
- delay the opposite equivalent subsequent action for the longest period, without adversely affecting the technologies primary function.

Noted technologies

Of particular note, the working group have identified a series of technologies and market enablers that are required to enable wide-spread domestic flexibility.

Domestic half-hourly metering – currently being rolled out through the UK's smart meter roll-out. It enables half-hourly settlement on a domestic level, necessary to enable most baselining methodologies and flexibility settlement.

Renewable generation – provides the source of low-carbon power. This is necessary for providing the variance in grid carbon factors through each day / season, from which smart technologies optimise to utilise low-carbon power whilst keeping the grid in balance.

Energy storage – be it thermal, chemical (incl. electrical) or potential is intrinsically necessary to bridge the gap between available renewable power and demand for that power.

Storage potential – is the measure of potential storage that could be unlocked in a property from existing devices. This is typically thermal storage in building fabric, domestic hot water tanks or storage heaters. A measure of the storage potential would be useful for building business cases and aiding migration of existing homes to flexible homes. Further work could be done to understand the necessary technologies to move existing intrinsic storage in homes into controllable flexible assets.

Register of flexible appliances – is a register of potential (not yet enabled) and available flexible appliances connected behind each MPAN. Particularly relevant for characterising the flexibility of heating and hot water systems, this register is necessary to aid network operators understand the available flexibility in any grid supply area. This subsequent informs network reinforcement planning.

Three-phase electrical connection – to enable homes with highest levels of flexible potential, a three-phase electrical connection is essential so the power in or out of the dwelling can be maximised.

Guaranteed diversity factor – is the ability for coordination between the flexible assets in the home to guarantee the power imported to or exported from the property, in any given moment, remains below a threshold agreed with the local network operator. This is necessary as it enables higher levels of flexible assets and renewable generation to be installed behind the meter, without increasing the burden on the local grid.

Real-time whole home energy monitoring – both of usage and import/export is necessary to ensure service providers are meeting contractual requirements, such as guaranteed diversity factors. It is essential that a 'single source of truth' is used for provider, agent and purchaser.

Connectivity – reliable, secure connectivity to flexibility aggregators outside the home, and to flexible smart appliances in the home, as well as to the grid meter asset, is essential to ensure the flexible service can be provided, and appropriately settled.

Open communication standards – enable device vendors and flexibility aggregators to readily communicate reliably and securely. It imposes the need for devices to be consistent. Work undertaken by the EPA and NREL[42] in the US has led the way with Energy Star and OpenADR respectively. Different standards exist for: Networks signals, APIs, autonomous response and remuneration.

Flexibility services marketplaces – provide a fair environment for homes (and/or an aggregator with a portfolio of aggregated flexible homes) delivering flexible services to be remunerated appropriately for the grid service they provide. Many UK DSOs are trialling models through the marketplace platform Piclo[43]. More marketplaces for flexibility services are required to underpin business models.

Recommended action

Assessing the presence of smart technologies could be done within SAP but calculation of savings would only be possible in conjunction with a model of a smart tariff (see section 3 below.) From the perspective of compliance, a simple checklist approach could be introduced for smart technologies, but this would require Government to define what they consider to be the target for new homes and would limit flexibility for developers.

A more detailed assessment of smart technologies in a building could be taken from the current development of a ‘Smart Readiness Indicator’ (SRI) for the European Commission, something that forms part of the revised Energy Performance of Buildings Directive.

The Working Group has reviewed the functions defined in the SRI as they relate to grid flexibility and believes that they could be utilised as a detailed compliance tool for new homes or could form the basis of a list of technologies to build into SAP. This extracted list can be found in Appendix B.

Recognising the nascent stage of both the UK flexibility services market and necessary smart flexible technology market, various actions are recommended to prepare a standard assessment procedure in anticipation for the roll-out of this technology within the UK:

- Gather evidence from the BEIS Domestic DSR trials and other sources to answer:
    - How much Carbon offset / savings are achievable?
    - How much Energy costs saved?
    - How the energy and carbon was saved
    - What classification of flexibility was deployed?
    - What are the relevant merits of each classification of flexibility?
- Gather a technology list for all compatible technologies, classifying their respective merits, particularly the level of flexibility they are able to provide. Levels to be based off the criteria identified previously in this section. (Most useful flexible technologies)
- Collate a forward view of future smart tariffs that would drive implicit DSR; necessary to underpin inclusion in a standard assessment procedure.
- Prepare a roadmap for domestic flexibility deployment (market and technology)
- Research and understand the existing DSR standards map globally
- Determine a suitable target for the level of flexibility (readiness) of new homes

[42] http://savannah.gnu.org/task/download.php?file_id=27590
[43] https://picloflex.com/dashboard

3. Smart Tariffs

An evolution of historic tariffs such as Economy-7 or Economy-11, smart tariffs are design to offer both consumers and generators of energy a flexible framework to reward a shift in their usage (or production) of energy. Typically, they're called Time of Use (ToU) tariffs and actively supported by BEIS Smart Meter Implementation Programme (SMIP) for both consumption and production (via the Smart Export Guarantee requirements). Smart tariffs are designed to encourage the use of time dependant renewable energy (such as wind or solar) as well as further supporting the overall supply dynamics of the wholesale market.

Import Tariffs

Traditional two-tier tariffs (e.g. Economy-7) required specific meters to facilitate the tariff structure, with an inability to vary this structure over time. With the emergence of the UK's smart meter infrastructure, it is now possible to remotely update the tariff structure of a domestic property without any change in infrastructure. This is particularly useful for the UK grid as a migration from centralised power generation and predictable demand profiles moves to decentralised generation and highly electrified heating and transportation demands. This increased variability of generation and demand, coupled with smart meter infrastructure provides the context for new, evolving smart tariff structures to emerge.

To date, most energy suppliers have evolved their traditional two-tier tariffs to either; extend their off-peak periods, to attract EV customers and influence when EV charging will occur; or are offering three-tier tariffs that follow the current use of system (DUoS) charges. Octopus are the exception, offering a half-hourly variable smart ToU tariff (Octopus Agile).

The Agile tariff tracks wholesale market pricing and accommodates the use of system charges, publishing 48 prices for the next day at 4pm. Whilst the amplitude varies with market pricing, the shape of the price curve is governed by the current DUoS regime, and is comparable to alternative three-tier tariffs. They offer 'plunge' pricing when there is a glut of renewable generation available to pay customers to use energy. At these times the non-energy costs are not fully reflected to amplify the variability and encourage positive consumer response. Restructuring of non-energy costs on the electric bill will aid the impact of smart tariffs on UK decarbonisation.

Mandated half-hourly settlement will likely move more energy suppliers to consider a fully variable tariffs, where wholesale market price variation is reflected in customer tariffs – akin to the current Norwegian retail market.

Under the current DUoS regime, the time at which each of the three pricing tiers occurs are predictable and align with traditional usage profiles. In 2019 the decision was made to move away from this tradition three-tier, scheduled DUoS structure from 2022[44] . A forward looking charges review is expected to produce a more dynamic metric, however, without any published guidance on this, it is difficult to predict the shape of smart tariffs over the next five years, let along from the mid-2020's onwards.

Before this change, it is realistic to assume that smart tariffs can be characterised into three bands, and SAP should look to reflect these new variants in the most recent update. A view of smart tariff structure in the mid-2020's is difficult to predict due to the impending changes to the non-energy cost structures and will be further impacted by the uptake of decentralised generation and the impact on standard domestic profiles due to electrification of heat and transport and mandatory half-hourly settlement.

Export tariffs

Currently SAP only accommodates FIT style export. SAP should be updated to accommodate the changes in domestic export payment arrangements.

[44] https://www.ofgem.gov.uk/system/files/docs/2019/12/full_decision_doc_updated.pdf

Today, all large suppliers are required to provide export tariffs (via the Smart Export Guarantee (SEG) scheme). Most offer a flat figure for generation, with at least one supplier offering a half-hourly variable export rate, linked to market price.

Work to date

As we depend more on renewable generation, the availability and cost of electricity will be less predictable[45], and flexibility must deal with this. In this case, practical systems will depend on a high degree of automation linked to a home energy management device or service. To allow the system to minimise the electricity bill, it would need to understand the home's daily power demands and how much they can be moved and have prior knowledge of the electricity price for each half hour period during the day. While we have not been able to identify any studies showing the potential savings impacts, the group are aware of activities within Octopus and geo that are trialling this approach. It is expected that saving data will be available as smart tariffs and DSR technologies become more widely applied.

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[45] Details of variance in electricity generation at any time can be seen through websites such as https://www.electricitymap.org

Recommendations for SAP 11

The incorporation of these within SAP 11 could deliver the following:

For **new build homes**, it could validate the savings potential for smart ready buildings. In terms of both cost and carbon, based on the level of flexibility available to the Building through the technologies installed, or accessible. To do this it would need to assess:

- All technologies installed or accessible (e.g. off-site renewables) that can offer flexibility, the level of flexibility and when it is likely to occur, and the interaction of all of these.
- The utilisation of the above against a modelled dynamic tariff. This could potentially be based on a 5 year forward looking tariff modelled on costs and carbon.

As a tool for **existing homes** (e.g. via an EPC) it could be possible to feed in forward projections for various tariffs available at a particular time. This could allow occupants to assess their potential to make cost and carbon savings by changing tariff, based on the degree of flexibility installed, or which could be installed, in their property. To do this SAP would need energy suppliers to provide specific, up to date information on their tariffs. There would also need to be a defined process to ensure that an up to date list of tariffs was available and this could logistically end up as an energy price comparison toll unless there was a defined level of granularity to avoid reflecting every individual tariff in SAP.

The incorporation of a two-tier carbon factor in the current version of SAP (SAP 10), covering both day and night carbon factors should be considered as a starting point for such assessments.

Further, an update to the export tariffing arrangements, from a standard FiT model to at least a two or three tier model would be desirable.

Improving the tariffs available for modelling in SAP10 is an imperative, and including a three-tier option and adding an EV two-tier tariff would be two easy ways to capture the current iteration of smart tariffs.

APPENDIX A – WORKING GROUP PARTICIPANTS

Organisation	Name
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Worcester Bosch	Chris Watling
Worcester Bosch	Stefan Kluepfel
Worcester Bosch	Andrew Robinson

APPENDIX B – SMART READINESS INDICATOR GRID FLEXIBILITY FUNCTIONS

Domain	Monitoring and control

	Heating and cooling set point management
level 0	Manual setting room by room individually
level 1	Adaptation from distributed / decentralized plant rooms only
level 2	Adaptation from a central room
level 3	Adaptation from a central room with frequent set back of user inputs

	Run time management of HVAC systems
level 0	Manual setting (plant enabling)
level 1	Individual setting following a predefined time schedule including fixed preconditioning phases
level 2	Individual setting following a predefined time schedule; adaptation from a central room; variable preconditioning phases
level 3	Control of run time management by artificial intelligence

	Remote surveillance of building behaviour
level 0	Not present
level 1	Remote control of main TBS
level 2	Remote control of main TBS with centralised occupancy detection
level 3	Remote control of main TBS with centralised occupancy detection, automatic non-occupancy default settings and user alerts

	Central off switch for appliances at home
level 0	None
level 1	simple off switch
level 2	off switch with ability for remote operation
level 3	sequence of deactivation for load optimisation

	Power flows measurement and communications
level 0	None
level 1	local use of sensor data
level 2	use of sensor data in microgrid operations
level 3	DSO based use of sensor data

	Energy delivery KPI tracking and calculation
level 0	None
level 1	local optimisation

	Fault location and detection
level 0	None
level 1	local based detection of errors
level 2	DSO optimised operations

	Neighbourhood energy efficiency calculation
level 0	None
level 1	local optimization
level 2	data exchange for local swarm and optimization
level 3	data exchange for local swarm and optimization for DSP vpp control

	Demand prediction
level 0	None
level 1	local optimization
level 2	adaptive load forecast

	Information exchange on renewables generation prediction
level 0	None
level 1	local optimization
level 2	adaptive load forecast

	DSM control of a device by an aggregator
level 0	None
level 1	microgrid operations (energy based)
level 2	VPP operations (price based)

	Energy storage penetration prediction
level 0	None
level 1	local forecast
level 2	microgrid based forecast

	Smart Grid Integration
level 0	None - No harmonization between grid and building energy systems; building is operated independently from the grid load
level 1	Building energy systems are managed and operated depending on grid load; demand side management is used for load shifting

	DSM control of equipment
level 0	Not present
level 1	Smart appliances or DHW subject to DSM control
level 2	Heating or cooling subject to DSM control
level 3	Heating and cooling subject to DSM control
level 4	Smart appliances, DHW, heating and cooling subject to DSM control

	Connecting PV to DSO grid
level 0	none
level 1	simple feed-in
level 2	CLS interface
level 3	DSO controls

	Reporting information regarding DSM
level 0	None
level 1	Reporting information on current DSM flows and controls
level 2	Reporting information on current, historical and predicted DSM flows and controls

	Override of DSM control
level 0	No DSM control
level 1	DSM control without the possibility to override this control by the occupant
level 2	Manual override and reactivation
level 3	Scheduled override of DSM control and reactivation
level 4	Scheduled override of DSM control and reactivation with artificial intelligence

Domain Electric vehicle charging

	Charging with local, building system-based control (price signal-based charging)
level 0	None
level 1	dumb charging on single tariff
level 2	adaptive tariffs structures with remote access

	Charging with aggregated control (EV responsible party as VPP balancing responsible party)
level 0	None
level 1	local optimization
level 2	local and grid optimization

	Charging with aggregated control (EV responsible party under a balance responsible party)
level 0	None
level 1	local optimization
level 2	local and grid optimization

	Grid connected heating for EV in wintertime
level 0	None
level 1	no grid sensor-based charging
level 2	grid-sensor based charging

	Providing system services to DSO operations
level 0	None
level 1	grid optimized operations
level 2	grid and battery lifecycle optimized behaviour

	Charging for optimisation of the EV battery lifecycle
level 0	None
level 1	car-lifecycle optimisation
level 2	car and grid lifecycle optimization

	Charging based on DSO price tags - " local wind storage"
level 0	None
level 1	storage
level 2	storage and feed-in to grid

	Vehicle to grid operation and control
level 0	None
level 1	exists

	EV Charging Grid balancing
level 0	Not present
level 1	1 way (controlled charging)
level 2	2 way (also EV to grid)

	EV charging information and connectivity
level 0	No information available
level 1	Reporting information on EV charging status to occupant
level 2	Communication with a back-office compliant to ISO 15118

Domain	Domestic hot water

	Control of DHW storage charging (with direct electric heating or integrated electric heat pump)
level 0	Automatic control on / off
level 1	Automatic control on / off and scheduled charging enable
level 2	Automatic control on / off and scheduled charging enable and multi-sensor storage management
level 3	Automatic charging control based on local availability of renewables or information from electricity grid (DR, DSM)

	Control of DHW storage charging (using hot water generation)
level 0	Automatic control on / off
level 1	Automatic control on / off and scheduled charging enable
level 2	Automatic on/off control, scheduled charging enable and demand-based supply temperature control or multi-sensor storage management
level 3	Automatic charging control based on signals from district heating grid (DR, DSM)

	Control of DHW storage temperature, varying seasonally: with heat generation or integrated electric heating
level 0	Manual selected control with charging pump on / off or electric heating
level 1	Automatic selected control with charging pump on / off or electric heating and charging time release
level 2	Automatic selected control with charging pump on / off or electric heating, charging time release and demand-oriented supply or multi-sensor storage management
level 3	Automatic selected control with heat generation, demand-oriented supply and return temperature control or electric heating, charging time release and multi-sensor storage management

	Control of DHW storage charging (with solar collector and supplementary heat generation)
level 0	Manual selected control of solar energy or heat generation
level 1	Automatic control of solar storage charge (Prio. 1) and supplementary storage charge
level 2	Automatic control of solar storage charge (Prio. 1) and supplementary storage charge and demand-oriented supply or multi-sensor storage management
level 3	Automatic control of solar storage charge (Prio. 1) and supplementary storage charge, demand-oriented supply and return temperature control and multi-sensor storage management

	DSM control of equipment
level 0	Not present
level 1	Domestic Hot Water production subject to Demand Side Management

- End of Appendix 8b -

Appendix 8c

WG3 HOME ENERGY STORAGE WORKING GROUP

1. EXECUTIVE SUMMARY

Meeting the Climate Change Act 2008 2050 target[46] requires drastic measures to be taken across all sectors of our economy. Focusing on the residential construction sector, and more specifically on new build, a number of recently published government milestones are noted:

a) **Future Homes Standard 2025 (England)**: It is expected that an average home built to this standard will have 75 - 80% less carbon emissions than one built to current energy efficiency requirements (Approved Document L 2013). It is expected that this will be achieved through very high fabric standards and a low carbon heating system
b) **Buildings Mission 2030**: Targets to at least halve the energy use of new buildings by 2030. For homes this will mean halving the total use of energy compared to today's standards for new build. This will include a building's use of energy for heating and cooling and appliances, but not transport
c) **Home of 2030**: Home of 2030 is a cross-departmental initiative funded by HM Government asking those in the industry to propose practical and scalable ideas for future homes, which are suitable for all ages and are environmentally sustainable over their entire lifespan. Home of 2030 will help develop widely applicable commercial solutions that make homes better and help develop low carbon technology so new homes can play their part in combating climate change.

Efforts are also being made to decarbonise the electricity grid and introduce non combustion-based technologies to address heating of new homes and hot water generation needs (such as heat pumps). Critical to the success of the efforts made is the appropriate evaluation of the impact of new construction methods and technologies to new, and existing, home improvements. Currently, nationally, in order to comply with the Building Regulations, the energy and carbon performance of new (and existing) homes is assessed using the Standard Assessment Procedure (SAP and rdSAP accordingly).

This report looks into home energy storage technologies and the role they have to play, progressing and supporting the delivery of the 2050 carbon target. Further technological benefits are also noted, including health and safety of use, contributions to energy supply resilience and consumer protection through reduced running costs. Opportunities, risks and challenges are reviewed both on the actual merits of each technology but also within the context of the SAP assessment outputs.

Opportunities identified:

Use of energy storage, combined with smart control strategies, will ease pressure on the already stretched energy networks and enable new low carbon heating solutions to be adopted. The main opportunities identified in terms of energy storage technologies aligned with their appropriate adoption and assessment within SAP (and similar tools) include:

- ✓ Energy demand and supply management, through dynamic energy storage and release
- ✓ The ability to introduce flexible, resilient decentralised supply demand networks using buildings as power stations

[46] It is the duty of the Secretary of State to ensure that the net UK carbon account for the year 2050 is at least [100%] lower than the 1990 baseline

- ✓ Impact reduction of increased electricity costs, protection of the consumer and support of transition to all electric net-zero carbon homes
- ✓ Introduction of interconnected systems and matrices, linking car batteries to home energy storage and optimising the utilisation of renewable energy generation on a local level
- ✓ Making regulations part of the solution, instead of part of the problem. Supporting the take up and appropriate evaluation of added value elements such as energy storage technologies through the approved compliance tool

In terms of the ability of SAP to evaluate and assess the impact of such technologies on the predicted energy and carbon performance of new, and existing, homes a number of challenges and limitations were identified, mainly due to the nature of SAP.

It should be noted that the proposed SAP10.1 is expected to introduce a number of changes within the assessment method, although it remains a steady state system. As a compliance tool, currently, it also only considers regulated energy loads (heating, domestic hot water, installed lighting and services and ventilation).

The impact of energy battery systems on building performance cannot be simply assessed using the existing SAP approach. The current approach is capable of calculating simple energy balances – achieved through a plethora of assumptions. It is not sufficient though to realise the benefits of more dynamic systems.

The following challenges are highlighted:

- ✓ SAP cannot assess the dynamic interaction of different technologies used in terms of energy storage and align those with specific utilisation patterns. That leads to limitations in terms of assessing the added benefits of these technologies associated with peak load management, energy cost management, live two way interaction with the grid and capturing carbon benefits achieved through grid energy use optimisation (off peak, low carbon timers etc).
- ✓ The variability of energy storage technologies (from electrical to soil batteries) – and the different patterns of use that may be required to be simulated in SAP, in a number of cases cannot be accommodated within the current SAP algorithms. Historic changes which the SAP methodology have also created complexities as to how the different calculation methods interact and affect each other. Incorrect assumptions used within SAP for energy storage will have a knock-on effect, introducing barriers on market-uptake and misinforming policy decisions.
- ✓ There is a lack of clarity and transparency on SAP scientific evaluation methods and evidence bases used for the assessment process. This creates the need for convoluted methods to be 'added-on' in each version of SAP. The introduction of new technologies is also delayed through the Appendix Q and Product Characteristic Database (PCDB) routes. Technology advances much quicker than SAP updates are implemented.
- ✓ The energy, carbon and cost factors used within SAP are 3- or 5-year average values. These are revised when SAP is updated creating a 'shock' effect for different technologies when this happens. At the same time, the energy cost and carbon factor fluctuations within a day are not captured, not allowing benefits realised through energy storage/release management from energy storage technologies to be fully captured.

Main recommendations include:

1. **Move from static to dynamic house energy and carbon performance evaluation**: it is of great importance that any building performance assessment tools, such as SAP, consider and properly evaluate the positive contributions of energy storage technologies. With emerging technologies in the

field of energy saving, storage and generation plus those that currently exist, there is a need to measure and future proof the performance of a dwelling in a different way from that in the current SAP/EPC methodology (Vivid Economics, 2019).

2. **Provide an appropriate route for the robust introduction of energy storage technologies within SAP:** New and existing energy storage technologies need to be assessed on their merits and introduced into the assessment tool. Currently technology advancement moves faster that the SAP update cycles. In the interim, going through Appendix Q and introducing a technology into the PCDB is a time consuming and inefficient process. The calculation methods used within SAP cannot properly reflect the benefit of energy storage technologies. It is recommended that a hybrid solution – potentially a two-stage compliance is occupied within SAP. The two stages will separate the fabric from the system's and energy storage performance. The latter can have a more sophisticated methodology sitting behind it, which can be updated more frequently.

3. **Perform a SAP gap analysis**: Identify the weaknesses within the current calculation methodology and limitations associated with the methodology itself, inputs required, energy storage technologies covered and incorrect assumptions that might be used. If a centralised system of storage asset registration existed then a holistic view of asset distribution would be possible, identifying gaps in capability and also enable aggregators to approach battery owners with schemes to manage the flexibility aspect – this would provide an income stream to asset owner and encourage competition in the aggregator space. Whereas at present some storage schemes tie you in for a fixed term of years of flexibility or is hardware specific (Tesla).

4. **Reassess how best to differentiate predicted performance from minimum compliance and how SAP can demonstrate enhanced added value to consumer based on modern features**: Delivering net-zero carbon buildings would require limiting the property's energy demand, as well as supplying them with low and zero carbon energy sources. Active load management through battery storage technologies, grid energy demand peak management (marginal grid carbon intensity management) and running cost reductions can all be addressed through the appropriate use of energy storage (Imperial College London). Greater consideration is needed to monetise and model different future energy scenarios to determine suitable cost factors and import/export tariffs as well as impact on asset value and the experience of the user.

5. **A rebranded SAP & EPC should be created**: the sensitivity of cost calculations based on technological solutions (installed services and features such as energy storage) will need to be noted within SAP outputs. Specific impact of technologies such as energy storage needs to be evaluated and explained. It is advised that there is a separation of the predicted fixed energy and carbon savings achieved through the buildings fabric and those achieved through the installed measured. With the introduction of smart meters, more monitored-based performance information should be collected and used to inform energy storage utilisation pattern predictions.

6. **Ensure a mechanism to support the National Infrastructures Commission's recommendation** to improve social housing energy efficiency to Band C by 2030 is acted upon, by using RdSAP as the tool to benchmark and incentivise social landlords to make improvements as part of their business plans. RdSAP to be modified as per previous SAP recommendations to enable appropriate recognition of installed energy storage systems.

7. **Signpost the impact of energy storage technologies on current and future grid capacity, and showcase value**: Peak demand can be reduced through several means including higher fabric standards, thermal or battery storage or using advanced control systems. Consideration should be given to whether standards can play a role in reducing the impact of new buildings on peak demand and how a future "Standard Assessment Procedure" can be used as a policy lever, "unlocking" market barriers behind and in front of the meter. The Passive House Planning Package (PHPP) tool used to assess compliance with Passivhaus standards does incorporate analysis of peak heating demand, and several other standards have emerged that could form the basis of further test to be applied.

Finally, adapting a pre-existing tool such as SAP to reflect new technological advancements, as in the case of energy storage technologies will prove challenging. SAP methods were historically developed to perform basic 'energy balancing' calculations with an 'energy loss' and 'energy input' linear system interaction. The energy battery storage systems as a 'dynamic' energy balance regulator extracting and introducing energy onto the system as per the system requirements. Additional carbon and cost benefits are achieved through their proper optimised utilisation.

Recognising SAP is a compliance tool, but commonly also used as a design tool, we would advise a rethinking of the SAP calculation process steps and outputs (EPC reports). It could be the case that SAP outputs are further broken down to demonstrate the impact of each decision on the score, introducing further performance thresholds.

We strongly recommended that in light of these findings, proper research work is conducted on how energy storage technologies are accurately assessed by SAP or any other tool, to avoid deceleration of technology advancement and innovation. Energy storage technologies have a critical role to play in delivering energy security, energy and carbon commitments.

2. METHOD

The main objectives for the working groups are as follows.

1. To establish the state of the art, sources of information and basic explanations of the technologies/systems expected to be mature in the mid-2020s.
2. To, if possible, outline improvements within the SAP modelling tool and suggest how compliance both on a product and dwelling level can be assessed.
3. If government decides to include recognition of the technologies and/or systems discussed within SAP11, to work with government and the SAP contractor to develop any additional details.

Home energy storage (heat and electricity) Working Group - Terms of Reference (Appendix One)

The group has explored energy storage technologies of various capacities (diurnal to inter-seasonal). The scope of works encompasses storage of heat in the ground (in both solid and liquid states), all types of electro-chemical energy storage and the review of emerging and innovative new systems and technologies.

The group closely coordinated with the other SAP IF Working Groups, particularly with the Domestic Hot Water and the Smart Controls Working Groups, in order to identify technology overlaps, avoid reporting conflicting statements and duplication of effort.

The role of the group was to consider, debate and contribute to technical and policy issues relating to the working group objectives and produce a report summarising its findings including:

1. **A list of any new/additional systems/technologies that the group thinks should be included in SAP 11. The list to be compiled based on market intelligence and stakeholder engagement.**

2. **Commenting on any broader issues likely to impact on the approach taken in SAP when energy storage systems /technologies are concerned.**

3. **Providing supporting evidence and Information sources relevant to developing any new/additional SAP methodology improvements required to accommodate for the technologies discussed – e.g. the key factors likely to determine the impact of the technology on the predicted carbon and energy performance of the dwelling.**

4. **Any other supporting evidence and relevant information (uploaded to the BRE evidence repository and included in Appendices).**

3 CONTEXT: The evolution of SAP

Significant changes have been made within SAP10.1 compared to SAP 2012. This included changes and updates in: fuel prices, CO_2 emissions and primary energy factors (plus the monthly variation of CO_2 and primary energy factors is now taken into consideration), the treatment of mechanical ventilation heat recovery systems (MVHR), flow temperature options for heat pumps and condensing boilers, revised self-use factors for electricity generated by Photovoltaic (PV) systems (allowing for the effects of battery storage to be considered), the inclusion of solar thermal space heating, the standard heating patterns used, heat loss data for heat interface units (for heat networks, now coming from the PCDB) and updates on the reference building characteristics .[47]

The sheer number of changes and modifications within the steady-state assessment tool indicated the need identified for a shift from straightforward energy balance calculations to more complex functions. The group noted the fact that energy storage systems, while historically in their simplest form as hot water stores have been included within SAP, would require special attention moving forward. This is specifically true for energy storage systems interacting with complex controls, and supporting the introduction of optimised, dynamic management of energy loads.

The schematic below (Figure 1), demonstrates how energy storage "sits" as a system capacitor but also as a regulator. The three commonly used energy storage methods have been classified as storing heat, hot water and electricity. The schematic also highlights the types of energy inputs / requirements used within SAP process (regulated energy use). These include energy consumption for the provision of space-heating, domestic hot water, lighting and ventilation**. SAP currently does not consider unregulated energy use.**

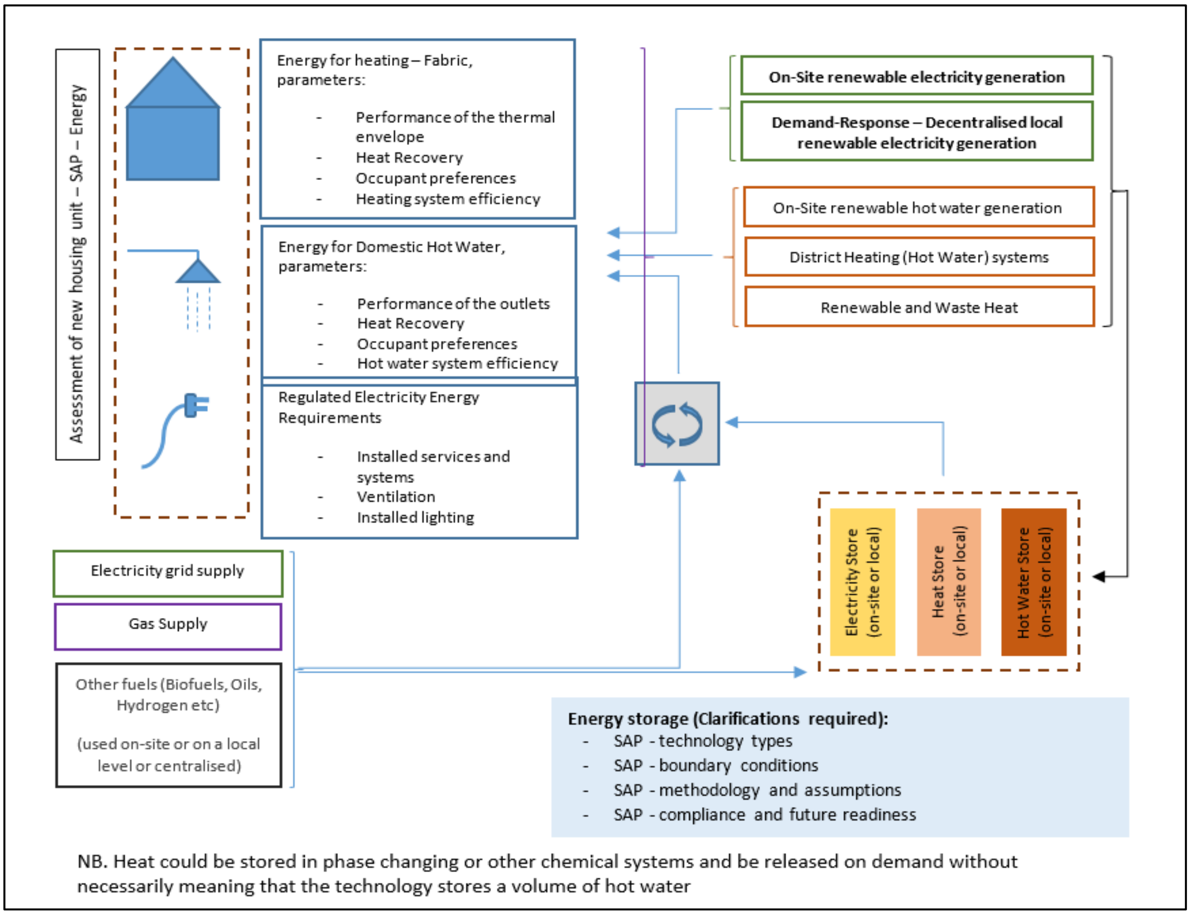

Figure 1 - Energy balance schematic signposting the dynamic relationship between energy generation, distribution and storage and SAP

[47] https://www.bregroup.com/wp-content/uploads/2019/11/SAP-10.1-08-11-2019_1.pdf

4. KEY CHALLENGES:

4. 1 Compliance & Assumptions

The unique nature of energy storage solutions, as a dynamic energy storage and exchange system, makes their appropriate assessment through SAP challenging. As the interaction between home energy storage and installed energy systems become increasingly sophisticated, how well can the continuous adaptation of the SAP historic method address and reflect the new technological requirements? Is it the case that overall compliance through SAP has been made easier through methodological changes that are too complex, and unsuitable for the appreciation of energy storage technologies? It was felt that SAP does not keep up with innovation or technology and is ill-suited for the future where time of energy use and management of energy balances become central to achieving energy and carbon reductions[48].

The following key SAP limitations were identified:

A) **Lack of provisions within the current SAP methodology to account for detailed predictability of energy demand fluctuations (daily, monthly, seasonal) and provisions for accompanying assumptions in terms of utilisation levels of energy storage technologies in support of maximising energy and cost balances**.

Current SAP and SBEM compliance models do not currently consider how energy storage technologies support the utilisation of low / zero carbon energy. Such an assessment would require the tools to predict how energy use patterns differentiate when using energy storage technologies and the benefits deriving from the ability to store and release energy on demand.

B) **If point (A) is addressed within SAP2025, challenges in terms of compliance and evaluation of technology contributions will persist. Across the lifetime of the energy storage solution, energy costs, carbon and primary factors will continuously change. Recognising the impact of this technology on the energy and carbon performance of a property – across its lifetime - at one point in time, during the assessment of the property, limits the benefits of the energy storage technology to evaluation through 'current factors' applying.**

One of the main challenges is less related to the technology itself and more to how it is used. For example, due to round trip efficiencies of battery storage it is possible to use more energy than simply not having storage without any benefit to the grid or local infrastructure in terms of increased self-consumption or local peak shaving, raising further concerns. Historically, SAP has been used to measure the energy performance of homes using gas and oil-based heating systems and is not geared towards capturing the energy performance of technologies that offer a range of diverse benefits and impact upon peak electricity demands. For instance, there is an increasing number of Electric Vehicles (EV) appearing on driveways.

C) **Further concerns include SAPs restrictive boundary conditions - SAP boundary conditions are not geared towards accessing the energy storage location and relationship with the property's energy balance**

Single and communal systems can attribute the benefits of the technology to the property they are installed within but also to surrounding buildings and the grid. The interplay of on-site energy generation, direct energy consumption and exportation of energy to the grid will need to be investigated. The cost savings associated with a specific installed technology, and the basis of the calculations also need to be noted and highlighted within the SAP outputs. The benefits of advances in storage technologies mean a dynamic relationship between technologies and energy use is enabled. This includes considerations around stand-alone, communal / locally

[48] SAP currently does not allow the combination of both battery storage and solar heating diverters. Furthermore, updates to SAP have inadvertently allowed negligible improvements to design to contribute substantially toward compliance. Building Regulations Part L, 2020 modelling identified the addition of flue gas heat recovery was able to contribute significantly towards achieving uplifts (Think Three, 2020), despite the fact this technology's role will be minimal with the transition toward the electrification of heat in new build.

centralised solutions and their recognition within SAP in terms of distribution losses, supply demand, peak load management, and flexibility of services, increasing the number of information input fields required within SAP.

4.2 Fuel Poverty: SAP assumptions for the generation of Energy Performance Certificates are misinforming policy and investment decisions & not protecting those in fuel poverty

EPCs are being used as a driver for Policy and Investment Decisions using inaccurate data. This is due to underlying assumptions within the SAP calculation process and the steady state nature of the calculation method. The methodologies used to generate EPCs are over 20 years old, and falling behind technology advances (UKCCC, 2019), resulting in homes being built to out-dated designs, using older technologies, passing higher fuel costs onto consumers, including those most vulnerable. This is of great concern. Given 10.9% of households in England and 12% in Wales are in fuel poverty, achieving Net Zero will require some challenging decisions to be made early on in order to ensure that companies and supply chains have sufficient time to adapt to the required changes.

Benefits of the operation of dynamic systems, such as energy storage technologies can be underestimated (or rarely over exaggerated). It could be the case that a different level of SAP calculations will need to be introduced to single out and review such systems' impact. The timing of these decisions will have major implications on what energy efficiency measures, storage and heating systems are put into place and when. The Committee on Fuel Poverty recommended the UK Government focuses on timescales for developing their plans for Net Zero: Social justice, Enforcing Housing Standards, Funding and Deployment (The Committee on Fuel Poverty (CFP), 2019). With emerging technologies in the field of energy saving, storage and generation plus those that currently exist, there is a need to measure and express the performance of a dwelling in a different way from that in the current SAP/EPC methodology.

Fuel poverty could be exacerbated if new homes continue to be built to low energy efficiency standards -the Committee on Climate Change (CCC) note that 8 per cent of homes built in 2018 were only at EPC D, and therefore already in line for a retrofit (Centre for Research into Energy Demand Solutions (CREDS), 2018) or with limited attention to the energy capture, control and storage potential each home might offer. For example, a study showed that one standard deviation measurement error decreases with EPC rating. This predicted error is higher than the limit recommended in UK guidance except in very efficient buildings and can also result in dwellings being rated in the wrong EPC band, for example it was estimated 24% of band D homes should actually be rated as band C.

A) **Fuel (energy) prices assumptions within SAP are revised following the SAP update cycles. These are based on predictions and don't reflect the actual expenditure, using prices averaged over the previous three years.**

Therefore, energy fuel bills for consumers are not being optimised and risk of fuel bill increases for consumers from the electrification of heat. The unit price used for 'electricity exported to grid' is the 2020 wholesale electricity price taken from Annex M of 'Projections of greenhouse gas emissions and energy demand from 2016 to 2035', 'existing policies' scenario. (It is not based on the export rate used for the Feed in Tariff).

B) **Tariff Structures and time of day use favours selection of some technologies over others, causing homeowners to have restricted access to products/services.**

Home energy storage can be used to reduce peak grid energy demand (5 – 8pm). However, this has benefits for the energy system without having any access to a revenue stream, e.g. storage enables utilisation of PV generated electricity beyond normal daylight hours, enabling increased self-consumption at times of peak demand. The addition of smart controls would enable further selective self-consumption periods either based on simple timers or externally triggered events such as via aggregators or tariff signals.

The complexity of the control system simply varies the efficiency and ability to effectively target times for storage and export. Thermal storage devices differ from all other heating systems defined in SAP due to their storage/flexibility. The decoupling of electricity demand from heating demand means they are able to be almost entirely flexible about when they use electricity. SAP forces assumption of only a 7-hour tariff for Dry Core Storage Boilers and the available tariffs do not include things like the new range of 5 hour EV tariffs, nor do they include dynamic tariffs such as ones currently on the market[49]. (Appendix Two)

4.3 Duplication of Home energy storage Technology assessment methodologies causes lack of interoperability between storage Registration platforms preventing data from being easily shared between system actors.

It is necessary for home energy storage technologies to be recognised within SAPs Product Characteristics database. SAPs Appendix Q and PCDB is a standalone technologies list and it can be a costly and time-consuming process to enable new and emerging products to be included in the list[50]. However, this database does not utilise other existing registers of energy storage technologies being used in the energy sector.
The lack of interoperability between current registration platforms mean data cannot easily be shared between system actors; instead data is collected solely for the specific purpose of the registration. Furthermore, as there is no simple way to register and amend registration information, those who do register may be deterred to update records across all registers. (ESC Energy Data Taskforce, 2019)

One challenge is selecting the correct technology. There is potentially insufficient information on the long-term performance of these systems, so mitigating some of the risks of poor specification should be included. In the first instance, availability of half hourly or better metering of building consumption should be specified so that a demand profile can be recorded - this enables effective assessment of the impact of the retrofit of batteries or other storage systems by ensuring it is done against a realistic demand profile. At present, insufficient granularity of energy use or inaccessibility of metering data means that when considering renewable generation or storage on site assumptions are made that may not be true and so the wrong technology could be specified.

Some form of provision for data collection should be considered and investigated further. The SMART metering program could be an enabler for this. However, access to the relevant data is often not possible and there is no interaction between suppliers, so changing supplier can result in loss of the availability of historic demand profiles and even holistic consumption.

There are significant gaps in the coverage of assets captured by registration systems that exist today. This presents real risks for energy system planning and operation, as system operators and regulators have little oversight over the assets connected to their system. As the installation of decentralised energy assets, including EVs and solar PV, becomes more prevalent, the problem will only become worse. The burden placed on consumers, small businesses and intermediaries aggregating assets, will be onerous and can reduce real registration. As new assets are developed there will be emerging needs to register with more organisations. For example, the Fire Brigade is a key stakeholder to be notified when batteries are installed at a home or an EV is purchased, as this can present a significant fire risk.

If a centralised system of storage asset registration existed then a holistic view of asset distribution would be possible, identifying gaps in capability and also enabling aggregators to approach battery owners with schemes to manage the flexibility aspect – this would provide an income stream to the asset owner and encourage competition in the aggregator space; whereas at present some storage schemes tie you in for a fixed term of years of flexibility or is hardware specific (Tesla).

[49] More data for benefits will come out of a number of projects, such as, BEIS's domestic DSR projects (Core4Grid https://www.geotogether.com/core4grid/.

[50] SAP Technical Manuals provide information on the calculation process as intended to be used by the SAP assessors. Information on the conventions and rules utilised to inform the methodology adopted and used from a scientific perspective appear in SAP technical papers, supportive guidelines, SAP Appendix Q, the BRE Domestic Energy Model (BREDEM 2012) as well as case study reports, research papers and notes published by the SAP Scientific Integrity Group.

5.HOME ENERGY STORAGE TECHNOLOGIES

All the energy storage systems identified require a form of energy input to be pre-charged (charging from local renewable or from the grid when cheap) and subsequently released when required. The charging time, capacity and general operation rules will be different between the different technologies, with some such as hot water stores contributions dictated by the domestic hot water demand SAP calculations.

It is important that any future SAP methodologies consider evidence-based calculation methods to best reflect the benefits of the diverse range of energy storage technologies available now and in the future and how best to take advantage of smart controls & energy management solutions.

Home Energy Storage Technology Types		Benefits
CHEMICAL	**Hydrogen/ Magnesium/Fuel Cells, SNG's and Hydrocarbons**	Production of hydrogen via the electrolysis of water and subsequent consumption to either produce electricity via a fuel cell or as an addition to the gas network. This is a potential route to effectively storing excess electricity, or supplement gas consumption for space heating. However, while some aspects of this process exist as a commercial offering, a self-contained, hydrolysis and storage and fuel cell or gas blend combination is not yet available at domestic scale. It is most likely that solutions based on this technology will be larger grid scale solutions in order to be financially viable in the short term.
MECHANICAL STORAGE	**Innovative technologies to harness kinetic (e.g. flywheel) or gravitational energy to store electricity. Or, hydroelectric etc.**	**While there may be a part for these systems in the wider energy storage landscape, these technologies seem unsuited to domestic applications at this point. Generally requiring large volumes of space or land to achieve economical storage capacities.**
ELECTRICAL STORAGE	**Electrochemical: Includes: advanced chemistry batteries (Lithium ion), Copper, Zinc, Lead acid), flow batteries and capacitors.**	Electrical storage is generally used in buildings to cope with the lulls (e.g. periods with little or no solar energy production) and slews (short-term changes in either supply (a lot of solar energy) or demand (a large power draw or reduced solar generation)). **Battery systems enable export of both spare power being generated at a point in time, and previously stored power to time-shift export, enabling peak shaving, tariff benefits, and carbon savings.**
THERMAL	**Capturing heat hot/ cold to create energy on demand or offset energy needs. Includes: Latent heat storage (phase change, Liquid air, Heat batteries, Electric Dry Core Storage Boiler, Hot Water storage, Inter-seasonal heat storage**	The true potential benefits of a solar heating system can only be realised if it incorporates the ability to store the heat for when it is needed the most. Thermal storage is necessary to retain heat generated by a solar thermal installation unit until the heat is ready to be used; and can be categorised as Sensible; Latent; or Thermochemical. Thermal storage can also be achieved from solar PV generation via the use of electricity to heat devices (immersion heaters or heat pumps) Solar immersion diverters are the most common and generally displace gas for domestic hot water generation. Less common, but emerging, is the use a variable power heat pumps that can also be used to convert excess solar to stored heat for hot water or space heating.
HEAT NETWORKS	**Community Heat Networks**	Large heat source servicing multiple users. Heat Network operator can respond to wider system signals on behalf of a group of individuals.
SMART (Active) BUILDINGS	**Smart Controls, Active Buildings & Active Building Technologies. Vehicle to Home batteries, vehicle to grid fuel cells.**	The novel feature of Active Buildings is their ability to function as part of a de-centralised power distribution system, acting as an "Energy Storage Asset" – the benefits will become significant when Active Buildings are aggregated through connecting buildings together, managing their energy and ensuring energy is distributed appropriately to meet needs. Electric vehicles (EV)s can assist with the smart operation of an Active Building by running their chargers in reverse, putting power back into buildings or the grid, at times of peak electricity usage or electricity shortage. As homes incorporate more technology aimed at increasing generation and self-consumption, the priority or flexibility of the control of these, often different systems, becomes more important for efficiency. Even determining and controlling the order of priority of use for excess generation can be complex. For example, if a household has an immersion diverter, electric vehicle and home storage then the choice of which to charge and in what order is where smart controls and modelling is required. The importance of monitoring and integration of systems is key to an efficient use of the available technology.

Established Home Energy Storage Technologies

The most widely used battery storage technology in buildings, particularly for home energy storage systems, currently are:

i) storage heaters for space heating,

ii) hot water tanks for hot water supply,

iii) electrochemical storage and other chemistries; lithium-ion (li-ion); but other emerging technologies exist, such as aqueous hybrid-ion (used in SPECIFIC's Active Classroom[2]); end-of-life car batteries (also li-ion); and flow batteries[3],

Current technologies on the market but not that widespread:

Thermal and electrical storage should be considered to mitigate peak demand, reduce the requirement to oversize systems, and enable greater control of energy.

- **Storing energy as heat:** 'heat' batteries store heat in a solid-state material with lower heat losses than hot water tanks and increased energy density (less space) – could also be used for space heating. The cheapest way to store energy as heat is to expand the use of hot water cylinders by connecting a renewable system to it. For more space-efficient solutions than a thermal store and potentially more flexible than a diverter, innovations such as heat batteries are becoming available (Sunamp). Heat batteries can be charged from either the grid or renewables, whether heat or electricity. Using "phase change materials" (PCMs) to capture and release energy from different sources and provides instant hot water at mains pressure.

- **Smart Homes & Smart Controls: Integration with Micro-Grids and National Energy Network:**

"Local Renewable Generation and storage is critical to reduce energy demand at point of use in buildings, reduce peak electricity demand and provide off gas heating solutions. There are strong links with actions now being taken by BEIS and Ofgem to develop markets for flexibility that will impact on SAP and our overall ability to truly assess the carbon intensity of products operational in a building. This includes the Ofgem review for targeted and forward-looking charges, as these will impact specifically on the value in the market for storage, but overall, how customer energy bills are constructed. In this instance, Ofgem need to have some statutory responsibility for long term decarbonisation of heat, and to understand the links between the design of SAP and actions taken for electricity market reform and how to adapt home energy systems to the increasing volatility of energy prices" (BEAMA).

There are already several solutions on the market using smart energy technologies, offering a wide range of batteries and grid sharing products and services. Home energy storage technologies and "Active Buildings" are also playing a role in smart energy management at grid level. These include batteries bundled with smart controls, including battery asset management software platforms, and hot water cylinders to store excess electricity, in return for preferential rates. A range of these services include the integration of advanced smart data management/ metering capability; learning, predicting and optimising home energy systems; automating scheduling and switching of Demand Side Response-ready appliances, to improve comfort and save costs. These are occupant preference, tariff and usage driven, and enable homeowners to maximise the usage of renewable energy, adopt EV technology and save up to 50% on their energy bills, by storing spare solar power or cheap electricity, ready to use at a time that suits them.

Benefits of these solutions:

a. Optimise time of use tariffs, by maximising solar self-consumption and generating revenues from providing flexibility services. Many smart storage systems allow you to keep track of your energy use online and charge the batteries with low rate electricity from the grid if you're on a tariff that is cheaper at certain times of day, such as Economy 7 or the newly emerging tariffs aimed at EV owners

b. Optimise use of Smart appliances reducing energy demand/ costs to consumers
c. Reduce energy bills for consumers (optimising time of use tariffs)
d. Cutting carbon; reducing fossil fuel heating demand from gas grid and able to target low carbon grid import
e. Provide a Fossil free Heat option / Off Gas heating options
f. Reduce fuel bills/ Designing buildings to protect from fuel poverty

- **Demand Side Response (DSR)**

DSR describes a type of energy service that large-scale industrial and commercial consumers of electricity, in particular, can use to help keep the grid balanced. DSR participants either decrease or increase their facility's power consumption when they receive signals (requests for help) to do so, thereby helping the grid to maintain its 50Hz frequency. As well as offering financial benefits, using DSR offers huge benefits to the Grid, helping stabilise the UK's electricity supply and enabling more use of renewable energy.

The true benefits of Active Buildings become apparent when there are many connected Active Buildings, capable of energy aggregation, managing and trading energy in a de-centralized power distribution network. Likewise, there are strong links with the delivery of the BEIS Smart Systems and Flexibility Plan and the future success of SAP as a compliance tool for the Building Regulations. The British Electrotechnical and Allied Manufacturers Association (BEAMA) has recently supported the launch of a report by Energy UK outlining the need to review the current Smart Systems and Flexibility Plan (Energy UK, 2020). This report highlights the crucial role of flexibility services, like energy storage and DSR, will play in reaching net-zero. The role, and capacity, for low carbon heating and storage technologies will play in delivering the needs of net-zero will be determined to a degree by assessment methodologies like SAP under the Building Regulations, so both markets and methodologies need to be designed hand in hand.

Could be on the market in 2025

- **Active Buildings: Buildings with Storage as an Energy Asset Class**

***"An Active Building supports the energy network by intelligently integrating renewable energy technologies for heat, power and transport* - For Active Buildings to contribute to and act as a part of the energy infrastructure, it is necessary for them to include some form of energy storage – electrical, thermal, or both".**

Active Buildings[51] aims to reduce the energy demand of buildings on the energy networks and, to do this, intelligent, proactive, energy management is essential to enable display of a 'flat' demand profile externally. This is achievable using sensors, metering, power tags, heat meters, forecasting, trading, optimization and monetarization. The aim of an Active Building is to have no uncontrolled import or export of energy. Characteristics of an electrical demand management strategy include:

- Reducing the building's demand on the grid.
- Equipping the Building Management System (BMS) with the ability to forewarn occupants of likely load peaks in advance.

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[51] ***The Active Building Centre's aim, through the Transforming Construction Challenge,*** is to design pathways to reduce the energy consumption of buildings. Bridging the gap between best practise design approaches for low energy zero carbon design, and the optimisation of energy generation and storage integrated with the energy infrastructure and Electric vehicles. Ongoing research and evidence building are currently underway to ensure that investments in renewables balance usage and storage of energy to best support the energy infrastructure. Using renewable energy as the prime source of electricity for an Active Building reduces stress on the main electricity grid and enables a smart building operation system to determine the optimum time to charge storage devices or export energy. The most common form of storage for electrical energy is batteries, although other technologies exist.

- Enabling flexibility and reducing peak loads, which reduces costs and eases pressure on the grid, and the creation of business models which allow value creation.
- Demand Side Response (DSR) provides an opportunity for Active Buildings to play a role in the operation of the electricity grid by reducing or shifting their electricity usage during peak periods in response to time-based rates or other forms of financial incentives. This enables dynamic energy pricing, as well as reducing grid stress.
- Predictive controls based on weather forecasts or occupancy calendars.
- Self-learning optimization based on occupancy patterns.
- Vector optimization, selecting the preferred energy source based on weather forecast, for example.

(See Appendix Three, Energy Storage for Active Buildings, Joanna Clarke, SPECIFIC)

Where appropriate Active Buildings integrate electric vehicle charging. As technology develops, bi-directional charging will allow electric vehicles to deliver energy to buildings as required.

The smart chargers used to exploit the power held in EVs must respond to the value of electricity, as well as the car user's requirements. For example, the charger could satisfy the user's requirements when the sun is shining and switch off the charger when the sun is obscured, or when other forms of demand increase, hence providing a useful service in balancing the grid. They could also be programmed to extract from the grid when the price of electricity is lowest and feed into the grid when the price for electricity import is highest or could be linked to the carbon intensity (CI) of the grid.

The electricity capacity of the grid to supply new housing developments is already struggling to provide enough power to support the installation of electric heating systems, such as Air Source Heat Pumps (ASHPs), as the UK's heat network is decarbonised – the added challenge of EV charging will only make the situation worse, unless smart charging regimes are implemented.

The UK government offers a grant of up to £500 towards the cost of installing a charge point in homes - from July 2019, all qualifying charge points must be smart, meaning they can automatically shift a vehicle's charging to off-peak times when there is less demand for electricity and prices are cheaper, saving money on energy usage.

- **Inter-Seasonal heat technologies** (***This technology is not yet commercially available)***
  - Thermochemical storage can be used in the following ways:
  - Storing solar energy generated in summer months for use in winter.
  - Storing waste heat from industrial/manufacturing processes and transporting this for use in housing.
  - Storing heat generated by one building to heat another that needs the heat, providing an alternative to expensive and energy intensive air-conditioning, which would otherwise be needed in, for example, office buildings. By drawing the heat away from a space into a thermal store, no additional cooling is needed, and the heat can be used where needed.

Alternatively, there are research projects aiming to synthesise thermochemical materials sets that would enable heat storage in thermochemical form. Many of these materials are based hydrated / dehydrated salt chemistries where provided the material is kept dry, no self-discharge during storage occurs. Once stored the energy is stored indefinitely provided it is kept dry, ready to be released via a moist airstream for use in space heating, or in combination with heat pump technology to increase its performance or operating window. These systems are not commercially available but significant effort is being expended in the drive to address the de-carbonisation of space and water heating (Baker, 2020)

A research group at SPECIFIC is developing a novel form of inter-seasonal heat storage, using Salt in Matrix (or "SIM") material, which can store thermal energy through a thermochemical process[10]. This has a much higher density than water, so is able to store more heat in a smaller unit and has huge potential to reduce energy use and fuel poverty. Thermal energy (heat) is stored by passing hot air over the SIM, creating a chemical reaction that locks the energy into the material. The reaction is reversed exothermically, meaning that heat is released, by passing damp air over the SIM. Provided the SIM is kept dry it will store the heat indefinitely. This makes it suitable for the inter-seasonal storage of heat and for transporting heat from one location to another (SPECIFIC).

While reducing imported heat for buildings and hence energy costs, this also has the potential to protect the environment from rising CO_2 emissions, helping the UK meet its Net Zero Carbon goal[11]. Use of industrial waste heat could also ensure that it is economically viable for manufacturing companies to remain in the UK, reducing their Climate Levy charges and reducing their fuel bills, hence providing economic stability for UK businesses. Research undertaken by Pinel et al. 2011[12] indicated that chemical storage can be up to as much as 34 times more energy dense than water.

- **Smart Grids/ Vehicle 2 Grid energy storage (same issues as 2-way electrical storage)**

In the future, it is likely that the batteries of electric vehicles (EVs) will be utilised as additional storage, whereby a householder can balance their household electricity use and transport needs. Essentially the vehicle becomes a mobile storage asset, being able to be used for building peak demand shaving and subsequent recharge during times of low demand, price or carbon, in a two-way movement of energy. With car manufacturers moving into the solar PV market it is expected that car solutions enabled to connect with appropriate home energy generation systems will become more common. In some instances, there are partnerships or a blurring of the boundaries between the energy and transport sectors. Tesla operates in all 3 areas, EV's, solar PV and battery storage. In addition Nissan recently confirmed a solar, storage and EV offering (https://insideevs.com/news/336050/nissan-launches-all-in-one-energy-solution-for-uk-solar-ess/). There are also some energy tariffs where the inclusion of a EV lease is part of the overall offering (https://www.octopusev.com/cars) and some innovative projects examining large scale V2G offerings (https://www.octopusev.com/powerloop).

- ***ASSURANCE***

Home energy storage systems should comply with Health and Safety requirements, in addition to other statutory compliance documents, such as Part P of the Building Regulations:

- HSE document 'Using electric storage batteries safely'[5]
- BRE 'Battery energy storage systems with grid-connected solar photovoltaics: A technical guide (BR514)[6]

A range of best practise guides also exists see Appendix Four

Case studies:

- ***Project ERIC: Moixa's ERIC project*** *(Energy Resources for Integrated Communities) in East Oxford, deployed 180KWh of smart energy storage across 82 homes, a school and a community centre. This has generated considerable data over two and a half years, showing how aggregate storage can act as a community asset, leveraging local solar and enabling peer to peer energy sharing.*

- ***Isles of Scilly:*** *Together with Hitachi and Passiv Systems, Moixa are delivering a £10.8m Smart Energy Island project on the Isle of Scilly – demonstrating how **an island smart grid and virtual power plant can manage distributed energy storage, electric vehicle, heat systems, renewables to balance local energy needs and reduce fuel poverty**.*

- ***Active Homes, Neath:*** *Active Buildings integrate renewable energy technologies for heat, power and transport. Active Homes are designed for high performance beyond the minimum Building Regulations. The homes use well insulated construction from SO Modular, solar technologies and the grid to provide heating. Dwellings within the Active Homes, Neath project have no gas supply. Instead they utilise BIPVCo solar PV and Tesla battery technology for power and TATA's transpired solar collector cladded wall provides heating in combination with Ariston's air source heat pumps (ASHPs). The project uses Tesla Powerwall batteries to enable solar generated electricity to be used later in the day as it is needed. When less sun is available, the batteries can be charged overnight, which is cheaper than charging during the day. A key element of the Active Building Centre is to collect data from buildings and people. The Department for Business, Energy and Industrial Strategy (BEIS) Building for 2050 project is conducting an independent review of the Active Homes development. BEIS will review the design and construction process and analyse energy performance data. BEIS will conduct social science research with tenants to determine occupant satisfaction.*

- ***Electric Nation project:*** *"Electric Vehicles (EVs) are becoming increasingly common on UK roads. The growth in EV ownership could cause challenges for the UK electricity industry if the adoption of electrified transport is widespread, especially if groups of neighbours buy EVs, creating localised clusters. These clusters could create issues on distribution networks – the networks that follow on from the National Grid transmission network and supply homes and businesses with electricity……..Every EV charging facility at home is equivalent to adding a new home to a network."*[14]

- ***Go Ultra Low***[15] *is a joint government and car industry campaign – supported by the Society for Motor Manufacturers and Traders (SMMT) and the UK Government's Office for Low Emission Vehicles (OLEV). Its aim is to provide all facts and information to enable consumers to make an informed decision about switching to an electric vehicle (EV) and choosing an EV-friendly tariff.*

The Active Office, SPECIFIC, 2018-19

- ***Electric vehicle integration:*** *During the first year of operation of the Active Office, 4.5 MWh of electricity (20% of total building consumption) was used to charge EVs using standard EV chargers. When the 'dumb' chargers are replaced with 'smart' chargers, charging regimes will enable control to ensure the best use of the available renewable generation while minimising the peak demand on the grid. Currently EV charging has a big impact on overall performance. It also highlights the future impact of electrification of transport and helps to identify future strategies for managing this increased demand, using Vehicle-to-Building (V2B) chargers, for example. All EVs used by the SPECIFIC are fitted with tracking devices, which will enable the smart charging regime to be implemented more effectively in future. Lithium iron-phosphate ($LiFePO_4$) batteries, were used in SPECIFIC's Active Office*[4]*, providing 110kWh of electrical storage. These consist of lithium-ion batteries, which use $LiFePO_4$ as a cathode material and a graphite carbon electrode with a* *metallic current collector grid as the anode. The battery system is supported by charge controllers and inverters, to manage the stored electricity.*

- ***Demand Side Response:*** *Controlled import and export of energy is currently being optimised at the Active Office. For the first 12 months of operation, this was relatively uncontrolled, simply based on a time schedule, but a new philosophy being developed will reduce overnight import and daytime export, thereby reducing round-trip losses and improving overall efficiency. The ultimate aim is never to uncontrollably import or export energy, but to target the most beneficial times based on carbon intensity or electricity price. The systems and extensive monitoring in place at the building enable it to act as a test-bed for other systems, such as operating as a Virtual Power Plant within a project called FRED[16], a collaborative project with Evergreen Smart Power; and an OpenLV project[17], which acts as a platform to explore ways that Active Buildings can interact with the grid utilising the technologies incorporated, such as heat pumps, EV chargers, battery storage and thermal storage.*

- The **FRED** Project (Flexibly-responsive energy delivery)[16] SPECIFIC is taking part in aims to explore DSR and its place in a low carbon energy system, using the Active Buildings to demonstrate Evergreen Smart Power's Virtual Power Plant platform with MyEnergi's zappi and eddi devices to mimic domestic heating and vehicle charging to enable flexibility in domestic energy supply.

- The **OpenLV** project, which involves monitoring the 450V LV substation on Swansea University's campus, is also underway. Data collected will be used to create an open intelligence platform at substation level to enable real time assessments of substation capacity and management. It also aims to establish a community engagement scheme which enables local communities to better understand their energy use and open up the substation data to academics and companies to create innovative services for the network. This sub-station monitoring and event triggering could form the basis for a domestic aggregated DSR platform and capability.

- *There are an increasing number of companies developing smart grid solutions. Some of these include:*
  - ***SNRG (Senergy):*** *a design and technology company focused on creating and integrating solutions to develop Zero-Carbon Co-Living Communities: https://www.oursnrg.com/*
  - ***Power Transition:*** *An Integrated Microgrid as a Service (iMaaS) software platform designed to help solve the challenges of the energy sector: http://ptvolts.com/*
  - ***Sero Energy:*** *provide an energy management service for homes, using the lowest cost and lowest carbon energy is used. They do this by combining all the homes they manage, with smart forecasting and energy storage; which enables them to buy electricity in bulk like a commercial user at the times of day or night it is cheapest; which means they can drive down costs for residents, while providing services that help support more renewable energy on the National Grid: http://www.seroenergy.com/*

  - *The* ***Electric Corby*** *Community Interest Company (CIC) supports a range of community project, such as:*

    Priors Hall Park in Corby, Northamptonshire *(47 new homes) uses a unique combination of technologies to reduce energy use to such an extent that every home will all be an ultra-low energy user and, in some circumstances, may mean no energy bills at all for residents. The Carbon Free Group has been working on the project since its conception, providing insights into new energy opportunities, helping to inform the design and build system methodology. Working closely with site* *developer, Project Etopia, and project partner, Caplin Solar, to deliver maximum energy efficiencies and ensure minimum energy use across all aspects of the development. Electricity, heating and hot water are generated by the homes themselves using a range of* ***technologies, including solar photovoltaic and thermal panels, heat pumps****,* ***heat storage and battery technologies.*** *These are all optimised by a* ***discreet smart home energy management system****, adopting an approach to the sustainability elements of the project through the implementation of the Home Quality Mark and M&E design including energy storage and building management to analyse how the 47 Corby homes will be using energy. This will enable significantly more efficient management of all the technologies in the properties. It will mean electricity, heat and hot water usage will be at very low cost in the homes, and potentially zero cost depending on energy usage. Your Community.Energy: a connected smart energy network that enables more renewable electricity generation with the aim of providing reduced energy costs for residents and businesses, http://www.electriccorby.co.uk/*

6. FUTURE METHODOLOGIES

a. **Dynamic Modelling: Advanced controls and 'smart systems' are likely to improve in-situ performance of the technologies utilised within buildings** (UKCCC, 2019)**.**

SAP currently predicts overall volume of regulated energy consumption but in the future it should consider how much energy is used based on energy consumption types (regulated and unregulated), where the energy comes from and when it is expected to be used (moving SAP from a 2D model to a 3D model)**.** If this is not possible then the SAP should be scaled back to assessing the predicted energy and carbon performance based on the heat loss characteristics of the structure. The impact of more sophisticated and dynamic systems will need to be then assessed through a tool that can better capture their actual contributions to energy and carbon savings.

In designing an energy integration strategy, consideration should be given to:

- National grid auxiliary services, e.g. aggregation of batteries and frequency response.
- Reducing peak demand, which is more important than overall levels of generation without a flexible approach to deployment, i.e. flexibility and reducing peak loads, hence reducing costs, not adding pressure on the grid, considering new business models, allowing value creation and enabling critical value extraction.
- The technical effects on local grid phases for sudden load or dump conditions.

For the renewables sector, connecting to the grid has become a primary barrier to deployment. This is relevant for multi megawatt (MW) solar farm projects as well as for the domestic retrofit market and housing developments with renewables, EVs or heat pumps incorporated into their design. A 'flexibility first' approach should be adopted to mitigate grid costs where possible, such as by ensuring that generation can be used locally, maximising self-consumption and that flexibility is incorporated into design, for instance by use of electrical storage and thermal storage. The Government, networks and regulator must start analysing the potential implications of policy recommendations on network costs, how best to manage these and when investment is required. Whilst this reason must not be used for delayed or subdued policy decisions, a full understanding of the network, potential reinforcements and therefore ways to mitigate this are imperative to ensure that the costs for transitioning to net zero are fairly distributed amongst end consumers.

The strategies of both the UK Government and Ofgem for regulating the future energy system and planning for a smart, flexible energy system has identified a number of key regulatory gaps, targeting to improve changes in 2023, including significant code review of network access and forward looking charging arrangements. This is of significant importance because the review will cover a plethora of market issues, yet the process does not explore options based on future proofing building performance standards and monetizing a future energy scenario where system operators and house builders are obligated to meet a minimum fuel poverty indicator to support government's Net Zero target.

b. **Boundary conditions**

Given the variability of the energy storage solutions offered currently by the market, and with the prospect of new solutions being developed into the future, the interaction between energy demand predictions and the balance of energy supply across the different boundaries needs to be clarified and investigated further. This is particularly important as there are significant cross overs emerging between buildings and energy management and storage systems.
Energy policy, Building Regulations, Planning & Energy Policy provide an opportunity to reduce energy demand, increase renewable energy capacity and improve infrastructure resilience. Energy storage technologies, decentralised networks, smart systems and controls should all be properly evaluated and included within the

various minimum planning requirements. The assessment of the planning applications should be made easy, so the increased housing delivery targets are achieved. A simple SAP or similar assessment tool should be able to itemise the impact of the different development decisions made, assess their benefits and highlight the risks. The assessment tool should be sophisticated enough to consider new and emerging energy storage technologies but simple enough to allow streamlined planning processes to be put into place. Appropriate guidance in terms of such technologies should be produced and be easily accessible and adapted to address any potential gap of understanding within the planning system.

c. Compliance & assumptions

There should be full analysis on the compliance routes SAP promotes and discourages and whether this fits in with the overarching government ambition for energy efficient and net zero carbon homes. Further investigations are needed to evaluate solutions available and calculation method used.

d. Reform cost & Tariff structures

Greater consideration is needed to monetise and model different future energy scenarios to determine suitable cost factors and import/export tariffs. For example,

1. Measuring energy performance in buildings accurately; Electricity price reforms / RIIO2/3
2. New Energy Performance Ratings for dwellings linked to energy system/ on off control.
3. Additional tariffs should be introduced as an option for assessors along with market incentives for Peak Generation time shifting
4. Electricity sourced from local renewables should carry different factors
5. Exported electricity should be given the same variety as the imported
6. Fuel price assumptions: SAP to use dynamic actual average projections as opposed to those reflected in table12

A particular concern of the Fuel Poverty Committee is that the marginal cost of electricity could reduce over time as more zero marginal cost production comes online (for example: solar, wind, nuclear and anything with a Contract for Difference). At the same time, the proportion of fixed costs could increase (fixed connection charges and payments for government policy). If this were to occur, there are two main issues:

i. That low users would be disproportionately worse off and paying for a greater proportion of the system changes than they would access; and
ii. If evaluated solely on cost savings to the consumer or marginal costs to the system, the incentives to save energy would be reduced as the marginal cost is low in proportion to the total bill. This can be observed a little now with the ½ hourly tariffs having significantly higher standing charges than the fixed tariffs effectively offsetting some of the benefit for low, but flexible consumers.

e. Regulatory levers: Making standards/regulations part of the Solution, instead of part of the problem

- **Smart Readiness Indicator (SRI)**

New rules under the Energy Performance Buildings Directive create a clear pathway towards a low and zero emission building stock in the EU by 2050 underpinned by national roadmaps to decarbonise buildings. Encouraging ICT to make buildings smarter, supports roll out of infrastructure e-mobility in all buildings and proposes to introduce a “smart readiness indicator” which will measure the buildings capacity to use new technologies, such as storage.

The methodology for the SRI is currently being developed by the European Commission. Although a voluntary measure, several elements within the SRI offer a mechanism to assess home energy storage systems capability to provide different market services, and the basis to make comparable assessments between buildings to aid the development of demand side market services. This is useful where aggregators are contracting with multiple dwellings; or to provide an assurance to the network operator that the provision is there for whatever service they are contracted to deliver, for example frequency response.

Industry feedback has also suggested, if the SRIs (or similar) framework principles are framed with the purpose of being a route to “explore” to transition the current “static” Standard Assessment Procedure (SAP) to a dynamic model it should be investigated further by BEIS, MHCLG, Treasury, Ofgem, the newly established ESO and others, because the energy and construction sectors are currently undergoing a number of significant changes and as the report indicates any future SAP cannot be developed without wider interaction with the energy system.

- Movement from a centralized to a more decentralized, digital system
- There is an increase in intermittent renewables
- An increase in new technologies (Renewable generation & storage technologies); smaller units that can evolve quickly and be deployed and low risk of regret. Vast increase in sensor, actuator and algorithm technology and deployment. Plummeting costs.
- Convergence of previously separate energy sectors of electricity, heat and road transport (increased competition through substitution of energy sources);
- The need to decarbonize heating

Within this context it is critical that regulators and policy makers ensure that all their decisions consider that there is a fair transition, and that the poorest in society are not left behind. As they stand, the Future Homes Standard proposals risk stifling innovation in how best to integrate the needs for domestic and nondomestic EV (and ULEV) infrastructure within the nature of the local built environment and energy system. This includes affecting steps being taken to support innovation in how storage technologies manage their interaction with wider energy networks, e.g. DSR, load shifting & predictive control methods.

The integration of EV’s and their charging arrangements in buildings and homes has much greater potential than simply ensuring homes and buildings are equipped for an EV. If a mandated approach is taken too early, then government is potentially mandating an approach which is similar to the first stages of the smart meter roll out i.e. in a rush to secure the expected benefits of smart meters, the UK has managed to install over a million meters, SMETS 1 meters, which are not future proofed, and ineffective in delivering an effective eco-system and infrastructure for meter innovation and development (we appreciate the DCC is now engaged in smart meter innovation).

(See Appendix Five – Proposed Smart Readiness Indicators Review of Active Office, SPECIFIC)

- **The Future Homes Standard**

The proposed Future Homes Standard (FHS) builds on the Grand Challenge Clean Growth Mission to at least halve the energy use of new buildings by 2030. However, proposals fall short of meeting industry expectation by not setting ambitious uplifts to the current energy performance requirements in Building Regulations for new homes needs to push further, ensuring future dwellings are future proofed to facilitate the adoption of low carbon heating technologies, avoiding the need to be retrofitted later and affordable for consumers to heat**.**

The FHS provides a good opportunity to make a step change in the way that dwellings are assessed and, separate out three distinct performance areas which SAP assumptions struggle to assess (Fabric, Primary Energy, Carbon intensity) and implement fair costs for energy usage at time of use; and to be used as a lever to futureproof regional plans for house builds to reduce peak load demands by enabling new homes built to become, for instance a new energy asset class, enabling EPC’s to indicate its actual predicted energy performance, smart readiness and be used as a robust indicator of fuel poverty; driving low carbon investment decisions, supporting long term policy objectives and ensuring the benefits of flexibility are assessed. (See Appendix 7: Thoughts on the future of SAP & EPC's).

Although an SRI in its simplest form is a measure of a buildings ability to interact with occupants and the grid. Capturing the building performance in quantifiable physical aspects and incorporating actual user behavior is not part of the proposed method[52]. However, this coupled with best practice standards approaches for better buildings performance standards, such as Passivhaus (Passivhaustrust), LETI (London Energy Transformation Initiative (LETI), 2020) , Active Buildings framework (Active Buildings Centre), Energiesprong (Energiesprong), Code for Sustainable Homes (Communities & Local Government), etc, has the potential to provide a robust backdrop to create a world leading FHS and ensures low carbon generation of heat and storage solutions meet compliance using a dynamic standard assessment procedure (Currie & Brown).

The Future Homes Standard (FHS) should not exclude transport, particularly because the energy regulator Ofgem and the Energy System Operator have concluded there is a strong case for considering fundamental reforms to its supplier hub model. This provides a "unique" opportunity for Building Regulations and the new FHS to be used as a catalyst for innovation in buildings and the energy system. National Grid have suggested that a deep penetration of EVs, smarter charging and V2G could increase peak electricity demand by 3-13GW by 2050 (CarbonBrief). While the methodologies occupied in estimating regulated energy demand are to a varying degree substantiated by existing case study and scientific evidence, the reach of SAP is not expected to accurately reflect and cover the complexity of new systems or accurately predict in use performance. However, alternative dynamic solutions may exist to replace the current static system.

The principle of the SRI could significantly aid the development of the storage market and demand side services for domestic consumers[53]. Whilst, providing a firm basis for energy service providers such as Distribution System Operators (DSOs) and aggregators to determine a building's capability to deliver demand side services to the market, the assessment process can include simple measures for:

- Stored capacity – electric/ heat/ hot water
- Capacity to shift load in the short term, capacity to shift/ supply electricity over a period in KWh
- Availability of a central home energy manager
- Availability of smart meter and associated data to the consumer
- External communication link into the property (via smart meter or cloud-based services)
- Availability and capacity of onsite generation & storage
- Control
- Automation

[52] SRI Topical Groups Feedback Meeting, 13 February 2020, Brussels
[53] BEAMA, Energy Storage by Design: Realising the Benefits of Energy Storage in Buildings

7. RECOMMENDATIONS & CONCLUSIONS

1. **Move from static to dynamic house energy and carbon performance evaluation**: it is of great importance that any buildings performance assessment tools, such as SAP, consider and properly evaluate the positive contributions of energy storage technologies. With emerging technologies in the field of energy saving, storage and generation plus those that currently exist, there is a need to measure and future proof the performance of a dwelling in a different way from that in the current SAP/EPC methodology (Vivid Economics, 2019)

2. **Provide an appropriate route for the robust introduction of energy storage technologies within SAP:** New and existing energy storage technologies need to be assessed on their merits and introduced into the assessment tool. Currently technology advancement moves faster that the SAP update cycles. In the interim, going through Appendix Q and introducing a technology into the PCDB is a time consuming and inefficient process. The calculation methods used within SAP cannot properly reflect the benefit of energy storage technologies. It is recommended that a hybrid solution – potentially a two-stage compliance is occupied within SAP. The two stages will separate the fabric from the system's and energy storage performance. The latter can have a more sophisticated methodology sitting behind it, which can be updated more frequently.

3. **Perform a SAP gap analysis**: Identify the weaknesses within the current calculation methodology and limitations associated with the methodology itself, inputs required, energy storage technologies covered and incorrect assumptions that might be used. If a centralised system of storage asset registration existed then a holistic view of asset distribution would be possible, identifying gaps in capability and also enable aggregators to approach battery owners with schemes to manage the flexibility aspect – this would provide an income stream to asset owner and encourage competition in the aggregator space. Whereas at present some storage schemes tie you in for a fixed term of years of flexibility or is hardware specific (Tesla).

4. **Reassess how best to differentiate predicted performance from minimum compliance and how SAP can demonstrate enhanced added value to consumer based on modern features**: Delivering net-zero carbon buildings would require limiting both the properties energy demand, as well as supplying them with low and zero carbon energy sources. Active load management through battery storage technologies, grid energy demand peak management (marginal grid carbon intensity management) and running costs reductions can all be addressed through the appropriate use of energy storage (Imperial College London). Greater consideration is needed to monetise and model different future energy scenarios to determine suitable cost factors and import/export tariffs as well as impact on asset value and the experience of the user.

5. **A rebranded SAP & EPC should be created**: the sensitivity of cost calculations based on technological solutions (installed services and features such as energy storage) will need to be noted within SAP outputs. Specific impact of technologies such as energy storage needs to be evaluated and explained. It is advised that there is a separation of the predicted fixed energy and carbon savings achieved through the buildings fabric and those achieved through the installed measured. With the introduction of smart meters, more monitored-based performance information should be collected and used to inform energy storage utilisation pattern predictions.

6. **Ensure a mechanism to support the National Infrastructures Commission's recommendation:** to improve Social housing energy efficiency to Band C by 2030 is acted upon, by using RdSAP as the tool to

benchmark and incentive social landlords to make improvements as part of their business plans. RdSAP to be modified as per previous SAP recommendations to enable appropriate recognition of installed energy storage systems.

7. **Signpost the impact of energy storage technologies on current and future grid capacity, and showcase value**: Peak demand can be reduced through several means including higher fabric standards, thermal or battery storage or using advanced control systems. Consideration should be given to whether standards can play a role in reducing the impact of new buildings on peak demand and how a future "Standard Assessment Procedure" can be used as a policy lever, "unlocking" market barriers behind and in front of the meter. The PHPP tool used to assess compliance with Passivhaus standards does incorporate analysis of peak heating demand, and several other standards have emerged that could form the basis of further test to be applied.

Other thoughts and considerations:

- Of significant importance is the timing for implementation of the new Future Home Standard (FHS) and commitment by Ofgem to implement market reforms to protect consumers from rising fuel bills and the need to urgently decarbonise heat.

- If high fabric performance / passive design is adopted, e.g. using Active Buildings principles, passivhaus standards etc, then space heat demand will be minimal, enabling all new homes to accept low carbon technologies without the need for costly retrofit in the long term, whilst limiting demand to domestic hot water.

- Further evidence and research is needed to scale up the application of low carbon technologies for heating in homes. i.e. through pilot studies. However, these must not restrict technologies and must be open to innovation.

- A regulatory framework is required to avoid disadvantaging existing or emerging technologies and passing unnecessary costs onto consumers. For example, further consultation with Ofgem and others is necessary to ensure the UK decarbonises to deliver a net zero economy at the lowest cost to consumers; enabling competition and innovation, both of which drive down prices and result in new products and services for heat.

- Synthesis with the Energy System market reforms to support decarbonisation of heat and as an indicator of fuel poverty. As a minimum, a new FHS should enable a building with generation & storage capabilities to be used as an "energy asset class"; the most cost-efficient route to demand and carbon reduction, these should be prioritized to future proof against costly retrofit in the future, with a higher CO^2 reduction in the long term. Enabling Part L regulations to use SAP as a policy lever to ensure all homes are designed to a "future proofed" high performance-based target ($KWh/m^2/yr$). This could be achieved through adopting the following principles:

  A) "**Future proofed" building energy and carbon performance metric**

  i) An efficient building fabric & optimized passive design to reduce operational energy
  ii) Regulated loads minimized using energy efficient services and low carbon heat
  iii) Where practicably possible building loads using onsite renewable generation & storage
  iv) Energy storage should also be considered to mitigate peak demand, reduce the requirement to

oversize systems, and enable greater control, enabling low carbon energy consumption (thermal stores with low output heat pumps, maximisation of low carbon energy generation, reducing grid stress and carbon intensity through arbitration).

B) **Innovation potential**

The Part L regulatory framework should avoid disadvantaging existing or emerging technologies and passing unnecessary costs onto consumers and protecting future generations. Homes should be designed to be equipped (if applicable) with the above and:

i. suitable energy infrastructure that allows import and export (i.e. two-way flow) of energy, on or off gas grid.

ii. control systems that allow market functions to be deployed to the benefit of the home user/owner (e.g. arbitrage, aggregation, variable tariff contracts etc.) as well as multi vector energy control to optimise direction of energy flow, including quality metering/monitoring/ comms functions (DSR/DSM)

iii. further consultation with Ofgem and others to assess the wider energy system benefits of buildings to ensure the UK decarbonises to deliver a net zero economy at the lowest cost consumers; enabling competition and innovation which drive down prices and result in new products and services for heat and reduce CO_2 emissions.

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APPENDICES

Appendix 1: SAPIF Terms of Reference

Appendix 2: The Importance Of Tariff Structures And Their Effect On SAP Ratings For Thermal Storage Devices

Appendix 3: Energy Storage for Active Buildings: Joanna Clarke, SPECIFIC (March 2020)

Appendix 4: Assurance

Appendix 5: Proposed SMART readiness indications review of Active Office, SPECIFIC

Appendix 6: Additional supporting evidence and information relating to Home Energy Storage

Appendix 7: Thoughts on the future of sap & epc's

APPENDIX ONE:

SAP Industry Forum: Terms of Reference

Purpose of the SAP Industry Forum Group

The purpose of the SAP Industry Forum Group (SAPIF) is to debate technical and policy issues as they relate to the National Calculation Method for energy rating of dwellings, comprising the Standard Assessment Procedure and Reduced Data Standard Assessment Procedure, collectively hereafter referred to as SAP. This will formalise an effective feedback loop for industry and other stakeholders, ensuring they have the opportunity to represent their views. This will facilitate the SAP Contract Contractors (BRE as Lots 1-3 and RDL as Lot 4) to gather industry views for communication to government and BRE. Additionally, SAPIF facilitates both government and BRE to put forward items for discussion and feedback.

This is different to the role of SAPSIG (the SAP Scientific Integrity Group) whose role is to help maintain and improve the scientific integrity of the SAP 'model of reality'. SAPSIG can be regarded as a (very) technical non-executive director helping the SAP contractor (BRE) develop new versions of SAP. It does not generally debate or consider policy questions.

Purpose of SAP

SAP is a calculation method to estimate the energy performance of UK dwellings. It is an asset-rating tool taking into account inter alia technical characteristics of the materials, products, and building services of the dwellings, some aspects of the external environment and applying a standardised user profile for heating and hot water use.

The Group should be mindful of the purpose of SAP, which is the assessment of the energy performance of dwellings in the UK, to help meet energy and environmental policy objectives and for regulation.

The accuracy of the SAP model should be no more than is sufficient for this purpose and over complication should be avoided.

The purpose of SAP is to provide an impartial assessment of the energy performance of a dwelling.

SAP should fairly reflect the evidence on performance of energy saving products. It is not the purpose of SAP to promote the sale of particular energy saving products, nor is it the intention to block or impede them.

The terms of reference for the SAP Industry Forum Group

Members of the Group are expected to possess a clear understanding of the role and scope of SAP, the Appendix Q process and the Product Characteristic Database (PCDB).

Terms of Reference of the SAP Industry Forum Group are:

- To consider, debate and contribute / participate in technical and policy issues related to SAP.
- To communicate industry views for onward communication to government and BRE and any other relevant organisation / body via the Secretariat.
- Where relevant, to proactively seek views from organisations they represent, to help ensure the success of this forum as the formal route for providing feedback and requests in relation to SAP.

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The work of the SAP Industry Forum Group

The Group's work plan is not yet set, being an early piece of work for the Group. However, in addition to dealing with questions relating to SAP, it is expected that the Group might want to consider matters of principle (such as wider decarbonisation policies or on amendments that might be proposed in order to address possible changes to the requirements of SAP). In general, these will be issues where BRE or BEIS has identified a need for their consideration / consultation.

Conflicts of interest

Members must be technically competent in their chosen area of work and behave in a professional manner. Impartiality is not a prerequisite, but members should be mindful of the privilege, as members, and declare conflicts of interest.

Should a potential conflict of interest arise at any time, the member concerned must notify the Group chair, who in turn will notify all other members, and this will be recorded in the minutes of the meeting. The Group chair has the power to exclude any member from the meeting if the conflict of interest is sufficiently great in the Chair's opinion.

Operation of the SAP Industry Forum Group

UK Government representation within the group is from the Department for Business, Energy and Industrial Strategy (BEIS), who are responsible for funding the development of SAP, and from the Ministry of Housing, Communities and Local Government (MHCLG), who are responsible for Building Regulations.

UK devolved administrations will not sit within the SAPIF, but their views will be sought and represented by BEIS and MHCLG.

One of the purposes of SAP is as a compliance tool for the Building Regulations. BRE, as the contractor responsible for its development, will seek to bridge and highlight issues regarding the Building Regulations or available technical standards that prevent the requested recognition of products/technologies.

The Group will normally meet between two and four times a year, subject to the amount of business requiring their attention. BRE will host these meetings and RDL will act as the secretariat. The Group can set up sub-groups for specific tasks.

Any correspondence from outside that is directed to the Group should be addressed to the secretariat.

If members of SAPIF believe that the Secretariat is acting improperly, they can contact Barbara Garnier (email Barbara.Garnier@beis.gov.uk) at BEIS in confidence to discuss their concerns.

In general, at the meetings BRE, RDL, government or industry members will be presenting topics / issues for debate and consultation by the Group.

The names (but not email addresses) of the Group members will be made public.
Documents recording minutes / actions / decisions of the meetings of the Group will also be made publicly available. However, documents intended for public view will be edited to preserve confidentiality where necessary. Meetings may involve discussions of confidential material, and that material and any associated notes from the discussions must remain confidential.

The Group may also conduct elements of its work outside formal meetings (e.g. by exchange of e-mail) wherever this would be an appropriate and efficient option.

There is no funding for undertaking any trade / product / service consultancy or new research work that the Group may identify and recommend. Travel expenses are not available for members of the Group.

Confidentiality

Members shall comply with RDL's SAP Contract Confidentiality Policy (SAPQA003) and Control of data records & software (SAPQA004); and will be required to complete RDL's SAP Contract SAPIF member Acceptance Form (SAPQA013).

Visiting experts / specialists or guests, will similarly comply with RDL's SAP Contract Confidentiality Policy (SAPQA003) and Control of data records & software (SAPQA004); and will be required to complete RDL's SAP Contract Specialist-Expert Acceptance Form (SAPQA014).

- End -

Appendix

Whilst not part of the Terms of Reference, the following items are included to inform the Group.

Mission Statement for the development of SAP / RdSAP

'The National Calculation Methodology for energy rating of dwellings (SAP / RdSAP) will be maintained and developed in support of Building Regulations and other Government policies, such as those that facilitate energy efficiency improvements.

SAP and the provision of SAP assessments must be sufficiently robust, providing consumer protection and minimising the risk that anticipated fuel bill savings are not achieved.

To achieve this, SAP must be reactive to a changing evidence-base and continuously seek to enhance accuracy. SAP must also support the recognition of innovative energy saving technologies, where relevant, whilst maintaining a robust and impartial assessment that preserves simplicity to minimise assessment cost.'

Energy Efficiency vs Energy Reduction Measures

Energy Efficiency Measures are defined as those that provide the same level of building service whilst reducing dwelling energy use. For example, a condensing boiler enables the same level of heating service to be provided with less energy than a non-condensing boiler.

Energy Saving Measures are defined as those that help occupants use less energy when they are willing to tolerate a lower level of building service. For example, a temperature controller may allow a heating system to adjust internal temperatures below standard SAP assumptions. These measures are not recognised by SAP, and depend on the extent to which occupants are willing to use them.

- End -

Change history:
Rev 2.0 Sarah Montgomery changed to Barbara Garnier

Appendix Two

THE IMPORTANCE OF TARIFF STRUCTURES AND THEIR EFFECT ON SAP RATINGS FOR THERMAL STORAGE DEVICES

What makes thermal storage devices different from all other heating systems defined in SAP is their storage/flexibility. The decoupling of electricity demand from heating demand means they are able to be almost entirely flexible about when they use electricity.

SAP forces you to assume only a 7 hour tariff for Dry Core Storage Boilers and the available tariffs do not include things like the new range of 5 hour EV tariffs, nor do they include dynamic tariffs such as Octopus Agile. The increasing penetration of solar and wind on the grid is causing wholesale power price dips at times of day other than the traditional night-time off-peak.

What's more, with roof-top solar, thermal storage devices can automatically get access to "free" electricity during the day. They can automatically soak up this daytime generation - reducing the requirement for imported electricity. During the summer and shoulder seasons this may supply a sizable proportion of the overall heating demand.

Lastly, thermal storage devices can provide grid balancing services such as Frequency Response to the national grid and DNOs. Direct electric heating and even heat pumps have little or limited flexibility about when they demand electricity as it's driven by heating demand. It is this form of direct electrification that will cause increasing strain on the grid around times of peak demand in the mornings and evenings. Instead, thermal storage not only moves these peaks but it can be used to automatically reinforce the grid stability at the points where it is most constrained.

You can see therefore that calculating the cost of running a Electric Dry Core Storage Boiler based on importing all energy on a standard 7 hour tariff makes no allowance for all the other cost reduction mechanisms available above which aren't available to devices like direct electric, oil or gas boilers. Our models show that for a 3 bed semi-detached house, a 40kWh dry core electric boiler, like the Tepeo ZEB, reduces the effective p/kWh by more than 66% compared with a direct electric boiler.

This is why boxing them into standard tariff structures does not work, puts them at a disadvantage and does not incentivise flexibility which will ultimately reduce the societal cost of reaching net zero.

Additional comments to Table 4a in SAP

The "heating type" for a Electric Dry Core Storage Boiler is classified as "2" but should be a "1" as it works with a radiator or underfloor heating system like a gas/oil boiler or Electric CPSU. It should also have a responsiveness of 1.0 like an electric CPSU, not 0.75 as is currently stated. It is very similar to a CPSU in that it is electric based but it just stores heat in a solid block rather than water.

In a heated space an electric dry core storage boiler is 100% efficient as stated in Table 4a. However even in an unheated space the efficiency across a year would be about 90%, not 85% if it has high efficiency insulation around it. We can provide data around this if required.

Appendix Three

Energy Storage for Active Buildings
Joanna Clarke, SPECIFIC (March 2020)

"An Active Building supports the energy network by intelligently integrating renewable energy technologies for heat, power and transport"

1.0 Introduction

The starting point for an Active Building is an efficient building fabric and optimised passive design to reduce operational energy. Both regulated and unregulated loads are further minimised using energy efficient systems. Where practicable building loads are met using building integrated or onsite renewable energy sources. In addition to reducing peak loads, and preventing oversizing of plant, the inclusion of electrical (including electric vehicles) and thermal storage allows careful management of the interaction with micro-grids and the national energy network. Intelligent control is essential for an Active Building, both for the control of building systems and to manage interaction and trading with the grid. Ongoing data capture will enable analytics and insight to feed back into the Active Building design process, and the development of predictive control strategies. Consistent data capture will be achieved by utilising a standard naming schema.

The novel feature of Active Buildings is their ability to function as part of a de-centralised power distribution system – the benefits will become significant when Active Buildings are aggregated through connecting buildings together, managing their energy and ensuring energy is distributed appropriately to meet needs.

Active Buildings should be designed in accordance with the following 6 key principles:

1. **Building fabric and passive design –** integrated engineering and architecture design approach including consideration of orientation and massing, fabric efficiency, natural daylighting and natural ventilation. Designed for occupant comfort and low energy by following passive design principles.

2. **Energy efficient systems** - intelligently controlled & energy efficient systems to minimise loads - HVAC, lighting, vertical transportation. Data capture via inbuilt monitoring & standard naming schemas to enable optimisation and refinement of predictive control strategies.

3. **On-site renewable energy generation -** renewable energy generation to be incorporated where appropriate. Renewable technologies should be selected holistically, given site conditions and building load profiles.

4. **Energy storage** - thermal and electrical storage should be considered to mitigate peak demand, reduce the requirement to oversize systems, and enable greater control.

5. **Electric vehicle integration -** where appropriate Active Buildings integrate electric vehicle charging. As technology develops, bi-directional charging will allow electric vehicles to deliver energy to buildings as required.

6. **Intelligently manage integration with micro-grids & national energy network** – in addition to intelligent controls, Active Buildings manage their interaction with wider energy networks, e.g. demand side response, load shifting & predictive control methods.

2.0 Energy Storage

Thermal and electrical storage should be considered to mitigate peak demand, reduce the requirement to oversize systems, and enable greater control of energy.

For Active Buildings to contribute to and act as a part of the energy infrastructure, it is necessary for them to include some form of energy storage – electrical, thermal, or both.

2.1 Electrical Storage

Using renewable energy as the prime source of electricity for an Active Building reduces stress on the main electricity grid and enables a smart building operation system to determine the optimum time to charge storage devices or export energy. The most common form of storage for electrical energy is batteries, although other technologies exist.

Battery systems have the following advantages when using renewable energy, such as solar, as the primary source of power for a building:

- Maximising the use of solar energy – generating during daylight hours and storing for use in the evening or the following day.
- Enabling building owners to choose when to use their solar energy and when to export it to the grid, demand shifting grid-connected electricity usage, through a smart control system. The control system can determine when to switch appliances on, when to charge electric vehicles, the optimum time to charge the batteries and when to export energy to the grid. This has the advantage of reducing pressure on the grid as well as maximising the use of solar, consequently reducing the amount of grid-electricity needed and hence reducing energy bills.

Electrical storage is generally used in buildings to cope with the lulls (e.g. periods with little or no solar energy production) and slews (short-term changes in either supply (a lot of solar energy) or demand (a large power draw)). This can be achieved with simple storage systems for relatively short periods of time (up to 2 days) but must rely on a smart system combining storage with demand-side response, shifting load profiles, for longer periods. Battery systems enable export of both spare power being generated at a point in time, and previously stored power to time-shift export, enabling peak shaving, tariff benefits, and carbon savings.

The efficacy of storage solutions can be measured according to different criteria:

- energy density (or how much energy is stored per kilogram of storage system)
- efficiency (how much energy is available for use compared to energy put in)
- lifetime (how many cycles of energy storage can be delivered before the system needs refurbishing)
- the maximum rate at which energy can be pumped into or out of the storage system (power per kg)
- the duration for which energy stays stored in the system; cost of the system; and safety[1].

The most widely used battery storage technology in buildings, particularly for home energy storage systems, currently is lithium-ion (li-ion); but other emerging technologies exist, such as aqueous hybrid-ion (used in SPECIFIC's Active Classroom[2]); end-of-life car batteries (also li-ion); and flow batteries[3].

Lithium iron-phosphate ($LiFePO_4$) batteries, were used in SPECIFIC's Active Office[4], providing 110kWh of electrical storage. These consist of lithium-ion batteries, which use $LiFePO_4$ as a cathode material and a graphite carbon electrode with a metallic current collector grid as the anode. The battery system is supported by charge controllers and inverters, to manage the stored electricity.

Battery storage should comply with Health and Safety requirements set out in the following documents, in addition to other statutory compliance documents, such as Part P of the Building Regulations:

- HSE document 'Using electric storage batteries safely'[5]
- BRE 'Battery energy storage systems with grid-connected solar photovoltaics: A technical guide (BR514)[6]

Common terminology explained:

Roundtrip efficiency:	The round-trip efficiency of electrical energy storage is the roundtrip DC-to-storage-to-DC energy efficiency of the storage bank, or the fraction of energy put into the storage that can be retrieved. Typically, it is about 80%.
Maximum charge rate:	The limit at which the system can charge the storage bank.
Minimum state of charge:	The relative state of charge below which the storage bank is never drawn, specified as a percentage of the total capacity. Most batteries are not meant to be fully discharged. The minimum state of charge is typically set to 30-50% in order to avoid damaging the storage bank by excessive.

Other less widely used forms of electrical storage include:

- Hydrogen fuel cells (if hydrogen is produced from renewables)
- Compressed air
- Flywheels
- Ice
- Electrochemical
- Immersion heaters in combined thermal and electrical systems

2.2 Thermal Storage

The true potential benefits of a solar heating system can only be realised if it incorporates the ability to store the heat for when it is needed the most. Thermal storage is necessary to retain heat generated by a solar thermal installation unit until the heat is ready to be used; and can be categorised as Sensible; Latent; or Thermochemical.

Sensible (short term: days):	utilises the heat capacity of material. Energy density is typically 30kWh/m^3. Sensible stores are typically diurnal systems such as water tanks or electrical storage heaters, but large volume examples exist, such as ThermalBanks™ by ICAX[7], which can store heat between seasons.

Diurnal heat storage enables heat generated during the day to be released into the building at night or early the following morning. The most commonly available diurnal storage system is water cylinders, incorporating copper coils or heat exchangers. The heating system for the Active Office utilises a 2,000 litre water cylinder, which stores heat generated by PV-T tubes and an air source heat pump (ASHP); and enables time-shifting of heating demand, with the capability to charge the tank on sunny days or overnight for use when it is needed to heat the building. A significantly smaller cylinder could be used in an Active House, similar to those used in conjunction with traditional gas-fired boiler systems.

Types of sensible storage:

- Water
- Thermal mass of building
- Thermal mass of ground

Latent (short - midterm: weeks):	heat physically changes a material either by melting, crystallisation or evaporation. Energy density is typically 70kWh/m^3

An example of a latent heat storage system has been developed by a UK company called Sunamp[2]. This is a compact heat battery technology, which consist of high energy density, high power density batteries which store heat generated from renewable electricity either via a heat pump or via a direct electric heater. This can replace the need for a hot water cylinder or gas-fired boiler and, if controlled by an intelligent energy management system, can optimise charging to use renewable energy when it is available. This system is well-suited to domestic buildings due to its compact nature but is also applicable to commercial and industrial use.

Phase change materials (PCMs) can be used in elements of the building fabric, e.g. ceilings, to replicate the effect of thermal mass, to avoid overheating in summer and to increase heat retention in winter.

Types of latent storage:

- Organic or inorganic phase change material (PCM)

Thermochemical heat storage (long-term: inter-seasonal):	Energy density is typically 140-830 kWh/m^3

A research group at SPECIFIC is developing a novel form of inter-seasonal heat storage, using Salt in Matrix (or "SIM") material, which can store thermal energy through a thermochemical process[10]. This has a much higher density than water, so is able to store more heat in a smaller unit and has huge potential to reduce energy use and fuel poverty.

Thermal energy (heat) is stored by passing hot air over the SIM, creating a chemical reaction that locks the energy into the material. The reaction is reversed exothermically, meaning that heat is released, by passing damp air over the SIM. Provided the SIM is kept dry it will store the heat indefinitely. This makes it suitable for the inter-seasonal storage of heat and for transporting heat from one location to another.

Thermochemical storage can be used in the following ways:

- Storing solar energy generated in summer months for use in winter.
- Storing waste heat from industrial/manufacturing processes and transporting this for use in housing.
- Storing heat generated by one building to heat another that needs the heat, providing an alternative to expensive and energy intensive air-conditioning, which would otherwise be needed in, for example, office buildings. By drawing the heat away from a space into a thermal store, no additional cooling is needed, and the heat can be used where needed.

While reducing imported heat for buildings and hence energy costs, this also has the potential to protect the environment from rising CO_2 emissions, helping the UK meet its Net Zero Carbon goal[11]. Use of industrial waste heat could also ensure that it is economically viable for manufacturing companies to remain in the UK, reducing their Climate Levy charges and reducing their fuel bills, hence providing economic stability for UK businesses.

Research undertaken by Pinel et al. 2011[12] indicated that chemical storage can be up to as much as 34 times more energy dense than water.

Note: This technology is not yet commercially available.

3.0 Electric Vehicle Integration

Where appropriate Active Buildings integrate electric vehicle charging. As technology develops, bi-directional charging will allow electric vehicles to deliver energy to buildings as required.

Electric vehicles (EV)s can assist with the smart operation of an Active Building by running their chargers in reverse, putting power back into buildings or the grid, at times of peak electricity usage or electricity shortage. Use of smart EV chargers throughout the country has the potential to provide a substantial amount of electricity when needed, comparable with some of the existing electricity storage facilities, such as Dinorwig in North Wales[13].

The smart chargers used to exploit the power held in EVs must respond to the value of electricity, as well as the car user's requirements. For example, the charger could satisfy the user's requirements when the sun is shining and switch off the charger when the sun is obscured, or when other forms of demand increase, hence providing a useful service in balancing the grid. They could also be programmed to extract from the grid when the price of electricity is lowest and feed into the grid when the price for electricity import is highest or could be linked to the carbon intensity (CI) of the grid.

Case Study: The Active Office, SPECIFIC, 2018-19
During the first year of operation of the Active Office, 4.5 MWh of electricity (20% of total building consumption) was used to charge EVs using standard EV chargers. When the 'dumb' chargers are replaced with 'smart' chargers, charging regimes will enable control to ensure the best use of the available renewable generation while minimising the peak demand on the grid. Currently EV charging has a big impact on overall performance. It also highlights the future impact of electrification of transport and helps to identify future strategies for managing this increased demand, using Vehicle-to-Building (V2B) chargers, for example. All EVs used by the SPECIFIC are fitted with tracking devices, which will enable the smart charging regime to be implemented more effectively in future.

Electric Nation project: *"Electric Vehicles (EVs) are becoming increasingly common on UK roads. The growth in EV ownership could cause challenges for the UK electricity industry if the adoption of electrified transport is widespread, especially if groups of neighbours buy EVs, creating localised clusters. These clusters could create issues on distribution networks – the networks that follow on from the National Grid transmission network and supply homes and businesses with electricity……..Every EV charging facility at home is equivalent to adding a new home to a network."*[14]

The electricity capacity of the grid to supply new housing developments is already struggling to provide enough power to support the installation of electric heating systems, such as Air Source Heat Pumps (ASHPs), as the UK's heat network is decarbonised – the added challenge of EV charging will only make the situation worse, unless smart charging regimes are implemented.
The UK government offers a grant of up to £500 towards the cost of installing a charge point in homes - from July 2019, all qualifying charge points must be smart, meaning they can automatically shift a vehicle's charging to off-peak times when there is less demand for electricity and prices are cheaper, saving money on energy usage.

Types of EV chargers:

Rapid Chargers (50kW DC, 43kW AC)	Capable of charging a 100% electric car up to 80% in 30 minutes. Often used in motorway service stations.
Ultra-Rapid Chargers (100 – 350kW DC only)	Allows EVs to charge at their maximum rated speed. Can deliver 100 miles of range in 10 minutes. Compatible with most EVs.
Fast Chargers (7 – 22 kW)	Depending on the size of the car battery, these can charge a car in around 4 hours. Often found on the street and in car parks.
Slow Chargers (up to 3kW)	The most common type of charger - often used in workplaces and homes. A standard charge can take 6 – 12 hours to charge a battery fully – suitable for top ups or overnight charging

Go Ultra Low[15] *is a joint government and car industry campaign – supported by the Society for Motor Manufacturers and Traders (SMMT) and the UK Government's Office for Low Emission Vehicles (OLEV). Its aim is to provide all facts and information to enable consumers to make an informed decision about switching to an electric vehicle (EV) and choosing an EV-friendly tariff.*

Summary Points:

- EVs have the potential to act as additional energy storage devices for a building through use of Vehicle to Building (V2B) chargers.
- Ideally EV charging regimes will be determined by the Building Management System (BMS), not by individual vehicles or chargers.
- EVs can add significant energy load to a building – controlling their charging regime will ensure they take energy either when need is identified through calendars, or when the building demand is low.
- Photovoltaic parking canopies can be used over EV charging stations to provide additional power and also to provide shading and cover for cars, reducing battery losses.

- Photovoltaic bicycle shelters can provide power for e-bikes, bicycle light charging, drying lockers, etc.

4.0 Integration with Micro-Grids and National Energy Network

In addition to intelligent controls, Active Buildings manage their interaction with wider energy networks, e.g. demand side response, load shifting & predictive control methods.

Ultimately, Active Buildings aim to reduce the energy demand of buildings on the energy networks and, to do this, intelligent, proactive, energy management is essential to enable display of a 'flat' demand profile externally. This is achievable using sensors, metering, power tags, heat meters, forecasting, trading, optimization and monetarization. The aim of an Active Building is to have no uncontrolled import or export of energy. Characteristics of an electrical demand management strategy include:

- Reducing the building's demand on the grid.
- Equipping the Building Management System (BMS) with the ability to forewarn occupants of likely load peaks in advance.
- Enabling flexibility and reducing peak loads, which reduces costs and eases pressure on the grid, and the creation of business models which allow value creation.
- Demand Side Response (DSR) provides an opportunity for Active Buildings to play a role in the operation of the electricity grid by reducing or shifting their electricity usage during peak periods in response to time-based rates or other forms of financial incentives. This enables dynamic energy pricing, as well as reducing grid stress.
- Predictive controls based on weather forecasts or occupancy calendars.
- Self-learning optimization based on occupancy patterns.
- Vector optimization, selecting the preferred energy source based on weather forecast, for example.

In designing the energy integration strategy, consideration should be given to:

- National grid auxiliary services, e.g. aggregation of batteries and frequency response.
- Reducing peak demand, which is more important than overall levels of generation without a flexible approach to deployment, i.e. flexibility and reducing peak loads, hence reducing costs, not adding pressure on the grid, considering new business models, allowing value creation and enabling critical value extraction.
- The technical effects on local grid phases for sudden load or dump conditions.

The true benefits of Active Buildings become apparent when there are many connected Active Buildings, capable of energy aggregation, managing and trading energy in a de-centralized power distribution network.

4.1 Demand Side Response (DSR)

DSR describes a type of energy service that large-scale industrial and commercial consumers of electricity, in particular, can use to help keep the grid balanced. DSR participants either decrease or increase their facility's power consumption when they receive signals (requests for help) to do so, thereby helping the grid to maintain its 50Hz frequency. As well as offering financial benefits, using DSR offers huge benefits to the Grid, helping stabilise the UK's electricity supply and enabling more use of renewable energy.

Case Study: The Active Office, SPECIFIC, 2019
Controlled import and export of energy is currently being optimised at the Active Office. For the first 12 months of operation, this was relatively uncontrolled, simply based on a time schedule, but a new philosophy being developed will reduce overnight import and daytime export, thereby reducing round-trip losses and improving overall efficiency. The ultimate aim is never to uncontrollably import or export energy, but to target the most beneficial times based on carbon intensity or electricity price.

The systems and extensive monitoring in place at the building enable it to act as a test-bed for other systems, such as operating as a Virtual Power Plant within a project called FRED[16], a collaborative project with Evergreen Smart Power; and an OpenLV project[17], which acts as a platform to explore ways that Active Buildings can interact with the grid utilising the technologies incorporated, such as heat pumps, EV chargers, battery storage and thermal storage.
The **FRED** Project (Flexibly-responsive energy delivery)[16] SPECIFIC is taking part in aims to explore DSR and its place in a low carbon energy system, using the Active Buildings to demonstrate Evergreen Smart Power's Virtual Power Plant platform with MyEnergi's zappi and eddi devices to mimic domestic heating and vehicle charging to enable flexibility in domestic energy supply.

The **OpenLV** project, which involves monitoring the 450V LV substation on Swansea University's campus, is also underway. Data collected will be used to create an open intelligence platform at substation level to enable real time assessments of substation capacity and management. It also aims to establish a community engagement scheme which enables local communities to better understand their energy use and open up the substation data to academics and companies to create innovative services for the network. This sub-station monitoring and event triggering could form the basis for a domestic aggregated DSR platform and capability.

4.2 Microgrids

There are an increasing number of companies developing smart grid solutions. Some of these include:

- **SNRG (Senergy):** a design and technology company focused on creating and integrating solutions to develop Zero-Carbon Co-Living Communities: https://www.oursnrg.com/
- **Power Transition:** An Integrated Microgrid as a Service (iMaaS) software platform designed to help solve the challenges of the energy sector: http://ptvolts.com/
- **Sero Energy**: provide an energy management service for homes, using the lowest cost and lowest carbon energy is used. They do this by combining all the homes they manage, with smart forecasting and energy storage; which enables them to buy electricity in bulk like a commercial user at the times of day or night it is cheapest; which means they can drive down costs for residents, while providing services that help support more renewable energy on the National Grid: http://www.seroenergy.com/

The **Electric Corby** Community Interest Company (CIC) supports a range of community project, such as:

- Etopia Corby: a development of 47 eco homes
- YourCommunity.Energy: a connected smart energy network that enables more renewable electricity generation with the aim of providing reduced energy costs for residents and businesses, http://www.electriccorby.co.uk/

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Appendix Four

ASSURANCE

IET Code of Practice for Electrical Energy Storage Systems

THIS CODE OF PRACTICE PROVIDES A REFERENCE TO PRACTITIONERS ON THE SAFE, EFFECTIVE AND COMPETENT APPLICATION OF ELECTRICAL ENERGY STORAGE SYSTEMS.

IET Code of Practice for Building Automation and Control Systems

The aim of this Code of Practice is to provide knowledge, understanding and good practice guidance on the design, evaluation, implementation and improvements to the use of automated controls used in mechanical and electrical engineering systems within the built environment.

IET Guide to Energy Management

This Guide should be used by all those with specific or delegated responsibility for managing the procurement, consumption and control of energy. This would include energy, facilities, building and environment managers, project managers and engineers and associated building operation and support engineers and technicians.

BRE Batteries and Solar Power: Guidance for domestic and small commercial consumers Guidance for domestic and small commercial consumers considering a battery system to work alongside an existing or new solar PV system.

Batteries with Solar Power - A Technical Guide to the use of Energy Storage with Grid-Connected Solar Photovoltaic Systems - Guidance on energy storage for solar PV systems for installers. Covering available technology for grid connected domestic and small commercial systems. Providing information on time-shifting and off-grid functionality, different battery technologies and system integration.

MCS Scheme Pilot assessment underway for a new MCS battery storage standard.

BSI List of Home Energy Storage Technologies Standards – list has been uploaded to BRE SAPIF data repository.

APPENDIX FIVE: Proposed SMART readiness indications review of Active Office, SPECIFIC

The table below attempts to look at the proposed SMART readiness indications and make a judgement on where the SPECIFIC Active Office currently fits and where the systems are heading in future development.

Domain	Section	Level 0	Level 1	Level 2	Level 3	Level 4	Comments
Monitoring & Contol	1. Heating and cooling set point management	✗	✗	✓	✓		Each Room has individual setpoints that can be centrally control with appropriate authorisation Option for a limited timed boost with automated setback to standard temps at the end of the day
	2. Run time management of HVAC systems	✗	✓	✓	✓		Time Schedule exists with fixed pre-conditioning period based on season. 2 individual AHU's controlled independently Fuzzy logic based prediction of heating load based on weather forecast, either vary preconditioning time period or increase instantaneous power via water circulation temperature.
	3. Remote surveillance of building behaviour	✗	✓	✓	✗		Detailed visibility of all building systems via individual systems and Main aggregated building management system Binary and people counting occupancy sensors available but not yet integrated into control. Relative slow heating response time of low temperature air systems means control of individual spaces by occupancy impractical.
	4. Central off switch for appliances at home				✓		Limited control of switch off sequence for load optimisation based on contactors for primary loads (DHW immersion, thermal store immersion) Variable load controllable for EV charging
	5. Power flows measurement and communications			✓	✓		DSR Project has visibility and control of immersion and EV chargers. Key Data also available to potential aggregator / optimiser but no control yet. Aim would be intercept aggregator signal to control car charger and implement a building wide response using other significant assets.

Monitoring & Control	6. Energy delivery KPI tracking and calculation		✓	✓			Significant KPI and usage trend tracking available. Determination of total energy consumption, key energy usage categories, live operating cost and carbon intensity. May be an opportunity for a level 2, whereby anonymous usage data in shared on a per square meter basis for key usage categories. This would encourage gamification and easy direct comparison between building design and operation modes.
	7. Fault location and detection		✓	✓			Local errors messages from individual systems are logged and communicated via push notification in some cases Unsure of what this would entail : Might be worth feedback to DSO on success or failure of any aggregation commands. Eg. Aggregator request turn down of power consumption, but building unable to respond due to low battery and non availability of controlled loads.
	8. Neighbourhood energy efficiency calculation		✓	✓	✓		Inherently efficient systems and control, schedule and optimum setpoints Historic consumption comparison and grid import optimisation to target battery SOC, more dynamic control of import / export based on current price and carbon intensity. Aim to be better optimised to target price, carbon or resilience using storage as a buffer through high prices or carbon cost. Aim to have data exchange with VPP and informed operation based on VPP direction.
	9. Demand prediction		✓	✓			Local historic demand prediction and compared to estimated generation and storage capacity with an aim to manage the grid import/export at a static level Estimated generation comparison with estimated consumption compare and identify key periods to import or export based on surplus or deficit. Management of battery SOC for minimal uncontrolled import or export.
	10. Information exchange on renewables generation prediction		✓	✓			Generation forecast available at 15moin and 24 hrs ahead. Use predictions to manage storage SOC and consistent import/export at targeted key time periods based on price or carbon.
	11. DSM control of a device by an aggregator		✓	✓			Direct diversion of excess renewable to available storage – both heat and electricity VPP control of car charges – however not based on price (FRED Trial)

	12. Energy storage penetration prediction						further clarification of definition needs to be understood (does it refer to energy storage utilisation etc)
Monitoring & Control	13. Smart Grid Integration		✓				Time of use tariff, using a combination of import and forced export from storage Aim to use more dynamic inputs, these include 30min price and carbon data to determine best source of energy (grid or battery)
	14. DSM Control of equipment		✓	✓	✗	✗	Diversion control of DHW and EV charging capable visa external VPP commands Option for DSM control of thermal store via ASHP for space heating. No Cooling capability
	15. Connecting PV to DSO			✓	✓		Current limiting device in place Capable of receiving signal to control import/export – plans to include via VPP
	16. Reporting information regarding DSM		✓	✓			Current and historical DSM power and energy across all circuits Predicted DSM flows in 30min intervals will be key challenge – heavily dependent on weather prediction
	17. Override of DSM control				✓		Scheduled switch to VPP control of car chargers on Friday afternoons, scheduled switch back to manual control on Monday morning
EV Charging	1. Charging with local, building system based control (price signal based charging)		✓	✓			Mixture of dumb chargers on single tariff and SMART Remote controlled chargers – however not controlled based on Tariff Targeted SMART Charging using Price and Carbon as Triggers
	2. Charging with aggregated control (EV responsible party as VPP balancing responsible party)		✓	✓			Local optimisation via delayed charge and variable rate charging based on charger numbers Use carbon and price controls to vary rate of charge (and other building loads) using local inputs
	3. Charging with aggregated control (EV responsible party under a balance responsible party)		✓	✓			Local optimisation via delayed charge and variable rate charging based on charger numbers VPP control of charge to variable and controllable pattern as required by grid services. Implemented on a trial basis at present

	4. Grid connected heating for EV in wintertime						Not in target, could be scheduled but less relevant for pool vehicles
EV Charging	5. Providing system services to DSO operations		✓				Off peak charging capable, external signal input capable.
	6. Charging for optimisation of the EV battery life-cycle						Not currently in target. Unknown what best charging regime for extending battery life
	7. Charging based on DSO price tags - " local wind storage"		✓	✓			Crudely via red, amber green tariff or VPP control Availability of V2G hardware is limiting factor here
	8. Vehicle to grid operation and control	✓	✓				Availability of V2G hardware is limiting factor here
	9. EV Charging Grid balancing		✓	✓			During VPP trials. Some hardware load balancing exists Availability of V2G hardware is limiting factor here
	10. EV charging information and connectivity		✓	✓			Power delivery and total charge committed displayed and available remotely. No query of vehicle state of charge at present Building wide communication of charge complete, vehicle API interface to query SOC (currently limited by AC charging protocol). ISO Standard relates directly to V2G
	1. Control of DHW storage charging (with direct electric heating or integrated electric heat pump)		✓		✓		3 charge methods for thermal store – which in turn provides DHW via indirect loop. DHW supply determined by availability of solar thermal and solar PV availability with manual top up via timer schedule. Grid price and carbon intensity control targeted. FRED project enables control remotely via VPP too.

	2. Control of DHW storage charging (using hot water generation)		✓		✗		Timed top up if solar thermal and solar PV diversion insufficient
	3. Control of DHW storage temperature, varying seasonally: with heat generation or integrated electric heating		✓	✓	✗		Timed charge predominantly with disinfection cycle automated Historic hot water use to determine demand to prevent oversupply in a low demand building
	4. Control of DHW storage charging (with solar collector and supplymentary heat generation)		✓	✗	✗		Solar thermal automatically heats thermal store and thermal store provide hot water and space heating. Electric immersion top up if required.
	5. DSM control of equipment		✓				Part of the FRED project DHW controlled via remote VPP under trial conditions

✓	Achieved
✓	Some elements achieved
✓	Future Target
✗	Unachievable
✗	Some elements unachievable

APPPENDIX SIX

Additional supporting evidence and information relating to Home Energy Storage

ENERGY TRANSITION READINESS INDEX - https://www.r-e-a.net/resources/energy-transition-readiness-index/

REA 2019 ELECTION MANIFESTO - https://www.r-e-a.net/resources/rea-2019-election-manifesto/

FLEXIBLE FUTURES - https://www.r-e-a.net/resources/flexible-futures-report/

THE INTEROPERABILITY OF PUBLIC EV CHARGING NETWORKS REPORT - https://www.r-e-a.net/resources/the-interoperability-of-public-ev-charging-networks-in-the-uk/

Flexibility Solutions for High-Renewable Energy Systems - https://www.r-e-a.net/resources/flexibility-solutions-for-high-renewable-energy-systems/

OPPORTUNITIES IN ELECTRIC VEHICLE CHARGING AT COMMERCIAL AND INDUSTRIAL SITES - https://www.r-e-a.net/resources/opportunities-in-ev-charging-at-commercial-and-industrial-sites/

THE FEASIBILITY, COSTS AND BENEFITS OF THREE PHASE POWER SUPPLIES IN NEW HOMES - https://www.r-e-a.net/resources/three-phase-supply-rea-position-paper/

TAKING CHARGE: HOW LOCAL AUTHORITIES CAN CHAMPION ELECTRIC VEHICLES - https://www.r-e-a.net/resources/taking-charge-how-local-authorities-can-champion-electric-vehicles/

REview 2018 - https://www.r-e-a.net/resources/review-2018/

Batteries, Exports, and Energy Security - https://www.r-e-a.net/resources/batteries-exports-and-energy-security/

Building Britain's storage industry - https://www.r-e-a.net/resources/building-britains-storage-industry-2/

EV FORWARD VIEW - https://www.r-e-a.net/resources/ev-forward-view-2017/

Development of decentralised energy and storage systems in the UK - https://www.r-e-a.net/resources/development-of-decentralised-energy-and-storage-systems-in-the-uk-2/

ENERGY STORAGE IN THE UK: AN OVERVIEW - https://www.r-e-a.net/resources/energy-storage-in-the-uk-an-overview/

DEVELOPMENT OF DECENTRALISED ENERGY AND STORAGE SYSTEMS IN THE UK - https://www.r-e-a.net/resources/development-of-decentralised-energy-and-storage-systems-in-the-uk/

UK solar beyond subsidy - https://www.r-e-a.net/resources/uk-solar-beyond-subsidy-the-transition/

https://www.theccc.org.uk/wp-content/uploads/2019/05/Net-Zero-The-UKs-contribution-to-stopping-global-warming.pdf

https://es.catapult.org.uk/wp-content/uploads/2019/06/Catapult-Energy-Data-Taskforce-Report-A4-v4AW-Digital.pdf

Aurora on EV charging Unlocking commercial opportunities for EV charging , along with a new report on the Energy Transition Readiness (www.eaton.com/EnergyTransition, Knowledge Centre tab).

http://www.bre.co.uk/filelibrary/nsc/Documents%20Library/NSC%20Publications/88166-BRE_Solar-Consumer-Guide-A4-12pp-JAN16.pdf

http://www.solarblogger.net/2019/11/solar-pv-and-primary-energy-in-building.html

APPENDIX 7

THOUGHTS ON THE FUTURE OF SAP & EPC'S

With emerging technologies in the field of energy saving, storage and generation plus those that currently exist, there is a need to measure and express the performance of a dwelling in a different way from that in the current SAP/EPC methodology.

The Future Homes Standard is a good opportunity to make a step change in the way that dwellings are assessed and, in my opinion, separate out three distinct performance areas:

- **Fabric**
- **Energy Demand**
- **Energy Generation/Reduction/Storage**

Fabric

The 'Fabric First' message that was running throughout previous versions of Part L seems to have been somewhat lost from the proposals in the Future Homes Standard. As a householder, the fabric of the building is the reason why you are paying most of your mortgage or rent. It is tangible, and the quality of its construction is key not just to how it performs on a basic level – do the doors fit/taps work/windows shut but at the energy performance level – will the house stay warm and offer a healthy environment throughout the year?

A Fabric measure such as Fabric Energy Efficiency Standard (FEES) proposed by the Zero Carbon Hub takes the core elements of the fabric including how the 'joints' perform (e.g. wall/ceiling; window/wall and floor to wall) would give a good indication of how well and efficiently the Fabric will cope with handling the energy required to operate the dwelling.

This should be a separate section in the EPC and there should be no excuse why every house built should not meet the FEES target. If keeping with the traditional 'A' to 'G' lettering this should always be an 'A' rated fabric. If this is not possible then other letters could be assigned to performance below the required FEES target.

Energy Demand

This will be dependent on the space heating, hot water, lighting, cooling and ventilation demands of the installed systems in the dwelling. This could be measured in the standard way with the usual assumptions made in SAP around typical occupancy rate, heating patterns etc and will be able to give a typical cost of energy used. It could be displayed on the EPC as a separate section, once again with 'A' to 'G' lettering with the banding taken from typical energy demands for the dwelling type assessed.

Energy Reduction

This would consider the 'added extras' that can be available to the dwelling. Such measures as renewable energy from PV or Solar Hot Water, Waste Water Heat Recovery, Mechanical Ventilation and Heat Recovery, Energy Storage such as Batteries and Smart Controls. To use the analogy of cars, this would be the sunroof/leather seats/cruise control of the housing world, although better than that as it would allow a reduction in the second metric of Energy Demand to be achieved.

The area of Energy Reduction is the one that is the most difficult to model and quantify in SAP with making it into a dynamic modelling methodology. Whilst this would be very useful on a house by house basis for the buyer/renter, SAP remains a compliance tool and, as such, bespoke modelling is out of scope. By splitting out the Energy Reduction section in SAP and making it a separate section on the EPC it would be possible, using the same set of assumptions made in the Energy Demand section, to show the impact of better Energy Reduction measures through a simple sum:

Actual Energy Demand = Energy Demand – Energy Reduction

(measured in Kwhr with an estimate of cost saving and potentially, CO_2 saving)

It should also be possible to use this section to show an Energy Demand result more tailored to the prospective purchasers or renter of the property. Just by entering people in the household, preferred heating patterns and occupation times (to look at PV and battery storage benefits) a more accurate result than the generic SAP assumptions would be obtained.

By adding extra PV or batteries or Smart Controls the above equation would change, and this could be used as a tool by housebuilder to give customers an indication of the impact of these extras on energy bills and CO_2. It would also, from the perspective of the Government and Energy Providers, be of benefit as it would reduce national energy demand.

The level of Energy Reduction Measures on a dwelling could also be used as lever to incentivise the engagement of the public with the performance of the dwelling. Linking this to a reduction in Council Tax or perhaps, for a new build property, Stamp Duty would suddenly make the details of the EPC more interesting as they have the potential to save the householder some money.

Rebrand the 'EPC'?

At the moment, it may be that little attention is paid to the EPC by householders and there is more focus on the council tax band. There are also issues with the accuracy of the EPC's themselves. With the upcoming Future Homes Standard, it would be a good time to re-name and re-brand the EPC to better reflect its focus on energy and CO_2 reduction as we transition towards a net zero carbon society by 2050.

The new document could be used by housebuilders to differentiate new houses built to the Future Homes Standard. It could allow Government to incentive purchase of houses with extra Energy Reduction Measures by giving grants in a similar way to those available when purchasing a new electric vehicle.

Rob Warren (10/3/20)

[1] SRI Topical Groups Feedback Meeting, 13 February 2020, Brussels
[1] BEAMA, Energy Storage by Design: Realising the Benefits of Energy Storage in Buildings.

- End of Appendix 8c -

Appendix 8d

WG4 Overheating including prevention and cooling

OVERVIEW

Overheating in the indoor environment specifically in domestic homes, schools and healthcare settings has become of great concern to us in the UK. Overheating is a result of the heat gains associated with occupancy and solar heat gains trapped in the indoor environment, which are exacerbated by the continuing rise in global average temperatures and the improved insulation and air tightness standards in building regulations. Although it is granted these improvements have been necessary for mitigating heat losses during the winter, they impacted the resilience of the building stock to hot weather events.

With the rise in the number of buildings that overheat and the rise in the number of associated deaths these contribute to, it is now crucial that buildings incorporate design methods and technologies that mitigate overheating. The current SAP methodology attempts to assess the whole building for overheating and can miss diagnose highly glazed habitable rooms being at risk of overheating.

This working group represents industries that provide products and systems that can mitigate the impacts of overheating. The principles of why overheating occurs were outlined at the start of the working group meetings in a 'Context Document' to ensure all members were aware of one another's technologies before this leading document was produced. This document can be found in Appendix A.

The leading technologies that mitigate overheating and were represented in the Working Group are glazing, shading, thermal mass and ventilation. Therefore, the body of this document highlights the new technologies within each technology area that the group fees should be considered within SAP Appendix P by the mid-2020s.

GLAZING

1.1 New Technologies

There are several current and forthcoming switchable glass technologies that may need to be incorporated into SAP11 to help reduce the risk of overheating in dwellings.

Four of the main switchable glass technologies are:

- Suspended particle device,
- Thermochromics,
- Polymer Dispersed Liquid Crystal
- and Electrochromic.

1.2 Performance Characteristics

Typical values are quoted below but may vary dependent upon individual products from specific manufacturers.

Technology	Visible light transmittance (range) %	g value*
Suspended particle device	50 - 1	0.70 = 0.50
Thermochromics	62 - 10	0.67 – 0.44
Polymer dispersed liquid crystal	58 - 1	0.36 – 0.09
Electrochromic	60 - 1	0.42 – 0.09

* Technologies originating in North America tend to have solar control performance quoted in terms of Solar Heat Gain Coefficient in preference to g value.

Performance data will also change when combined with other products, for example in an insulating glass unit.

These technologies generally can be assessed for durability in accordance with existing standards, for example EN ISO 12543 and EN 14449 (product standard for laminated glass) for thermochromics, although additional test methods are planned in ISO.

Performance data is typically based on conventional standards for 'passive' glass, for example EN 410 (Determination of luminous and solar characteristics of glazing). An ISO technical committee, ISO/TC 163/SC 2/WG 15, has been set up to develop an international standard for determining the performance of adaptive glazing. Delivery of a standard is anticipated within 3 years.

The above technologies are described in more detail in the document *Adaptive / switchable glass technologies version 2 - Overview for SAPIF Working Group #4 Overheating - Phil Brown, 15th February 2019.*

1. Solar Shading

1.3 Background and Evidence Base

With years of historically cheap and plentiful energy and limited concern over the environmental consequences of greenhouse gas emissions, combating solar heat gains by simply ‘cranking up’ the air conditioning was considered acceptable. Unfortunately, air conditioning systems are exceptionally energy hungry. Today there is much more financial as well as ethical incentive to consider the solar heat gain performance of shading. This is because of the increased frequency of hot weather events which are predicted to increase the up-take of air-conditioning to improve thermal comfort in warmer weather periods as identified in the MHCLG report "Research into Overheating in Homes"[54]. Therefore, shading can no longer be viewed as a decoration at the window or a visual comfort measure.

Furthermore, improvements in the airtightness and insulation of homes (which help save energy costs when heating is used) is now causing issues with overheating at other times of the year (House of Commons Environmental Audit Committee, 2018).

The benefits of solar shading are proven in their ability to mitigate overheating (*See section 2.2 Solar Shading Evidence Document*) and reduce energy consumption (*See Section 5 Solar Shading Evidence Document*).

Lord Krebs, who chaired the Committee on Climate Change stated:
"A lot of modern flats are built with limited ventilation. We are not designing buildings for preventing overheating. Shading – shutters or awnings – is not costly or difficult to install, it's just that we're not doing it."

Shading must be considered as part of the building services package and the specification followed through to build. To date shading is recommended in several design guidance documents (*See Section 3 Solar Shading Evidence Document*).

Nevertheless, historically the attitude to shading has been "we cannot recommend a solution that the consumer might not use". That has led to regulatory overheating assessments devaluing shading due to occupant usage and therefore favouring fixed solutions which can negatively impact energy consumption in winter. A 50% penalty applied to shading devices within Appendix P alters a gtot value of 0.05 to 0.525, a drastic reduction in effectiveness.

Additionally, it is not conceivable that an occupant suffering from overheating would not use shading if it was available to use, like a person not using their heating if they were cold in winter. The attitude should be to inform and educate users of buildings, so they use them efficiently and effectively, as is the attitude towards central heating thermostats regarding energy savings.

Nations promoting the use of shading as part of the solution to buildings overheating is growing on the continent. In other countries tax incentives are used to encourage the incorporation of solar shading and new regulations are being proposed where shading is relied on to mitigate the number of overheating hours. Austria, The Netherlands, Italy and

[54] https://www.gov.uk/government/publications/research-into-overheating-in-new-homes

the Czech Republic are some of those countries that are either currently or are proposing to encourage the integration of shading further (ESSO, 2019).

1.4 New Technologies and Performance Characteristics

Performance Data

Inaccurate modelling due to poor representation of shading performance values is a major hurdle to overcome to realise the true benefits of shading (ES-SO, 2018). SAP, as do other software tools, still use outdated methods of calculating the thermal performance characteristics of shading systems that do not comply with EN Standards[55] (*See Section 2 of Solar Shading Evidence Document*). Verified shading performance data is freely available online and is now being integrated into a global database supported by Lawrence Berkeley Laboratory and the Fraunhofer Institute[56] (*See section 2.1, Solar Shading Evidence Document*). The European Solar Shading Organisation (ESSO) has also set up educational campaigns to improve knowledge and awareness within the shading industry and to consumers (ES-SO, no date).

Motorisation and Automation

Innovations in shading systems now provide the opportunity to automate shading systems to encourage improved user behaviour based on external and internal environmental conditions (BRE, 2017) (*See section 5, Solar Shading Evidence Document*). This innovation in technology is supported by the Energy Performance Building Directive Recast (2018) which has been furthered by the proposal of a Smart Readiness Indicator (BPIE, 2019) which has led to the development of EN ISO 52016 (BSI, 2017) which addresses automated facades. This standard is currently being further developed in ISO/WD 52016-5 which will provide a specific criteria and validation procedures.

Incorporation of automation and user control strategies for shading is a complex issue to incorporate in SAP however the business case for improved energy efficiency is proven. This has been discussed more thoroughly in the Separate documents titled *'The Need for Dynamic Shading'* and *'Total Building Automation in SAPIF – Discussion Document'*.

1.5 Additional Comments

We can appreciate the need for case studies but for shading and glazing it is not as simple as installing units in multiple premises and measuring the power usage. We are attempting to measure the effects of a constantly changing power source, the sun, and measuring not only the multiple effects but also the psychological effects on the occupants. The case for shading is simple and proven in preventing solar gain and is more cost effective and

[55] These metrics are also supported in the BRE 'Solar shading of buildings: Second edition'.
[56] This initiative is called the ICON project which will expand the International Glazing Database (IGDB)(Lawrence Berkeley National Laboratory, 2019) to the International Shading and Glazing Database.

environmentally much less damaging than installing and using air conditioning to remove it however, quantifying that benefit in regulation is the issue.

THERMAL MASS

1.6 Issues with SAP Methodology

The thermal mass of a building element is its ability to store heat and provide inertia against temperature fluctuations. As an integral part of building fabric, if designed well, thermal mass can provide a 'user friendly' contribution to the prevention of overheating. There is the potential to introduce thermal mass 'backstop values', similar to the limiting fabric parameter (U-value) for individual building elements with the view to avoid overheating risk in lightweight buildings.

As thermal mass plays an important role in the overheating risk of a dwelling, it should not be overlooked or diminished in SAP 11, in fact it would be more appropriate to consider a new, more complex methodology for calculating thermal mass to improve the overall assessment of overheating. In addition to this, there is a call for more dynamic modelling of internal temperatures and overheating risk as opposed to steady state calculations (suggestions already include the use of CIBSE TM59 (CIBSE, 2017)).

There are limitations to current SAP methodology in respect to the calculation of effective heat capacity of construction materials. This is based on a simplified method (Annex C in BS EN ISO 13786:2017 (BSI, 2018)) which assumes the maximum effective thickness (maximum depth heat can penetrate in a 24 hour heating/cooling cycle) of construction materials is 100mm.

However, this is only representative of dense materials such as concrete. For lighter materials, such as timber, it is overestimated which in turn overestimates its effective thermal capacity. Actual effective thickness can range from 40% to 120% of the current conventional value (40mm – 120mm). This highlights that the current simplified method is no longer adequate and a more accurate (more complex) method (such as that outlined in BS EN 13786:2017 (BSI, 2018)) should be used.

To illustrate the issue, a CLT (cross laminated timber) wall section at 200mm thick would have a k value of 65 kJ/m^{2}K based on the effective thickness of 100mm. In reality, only the first 40% of depth is effective for pine wood and so the true value is actually around 26-30 kJ/m^{2}K, half of the value currently included in SAP. This leads to an underestimation of the overheating risk in CLT buildings and those made from other lightweight insulating materials.

VENTILATION

1.7 New Technologies and Evidence Base

Automated and sensor-controlled natural ventilation solutions
This has been found to provide the best performance and technology that should be considered as regards future SAP methodology.

In France (Paris area), measurements conducted during a joint research project between VELUX and Ecole des Mines de Paris has shown that "during typical indoor and outdoor conditions – wind speeds between 2 to 3 m/s and temperature a difference lower than 3 °C – Air Change Rates between 10 to 22 h -1 have been achieved". The conclusion of the project also stated that, when extrapolating the learnings thanks to numerical models, "indoor temperatures have then been reduced by 5°C on average thanks to ventilative cooling".

Accurate Natural Ventilation
Recent advances in standardization are now providing reliable air flow rate models to allow for the use of natural ventilation through windows in summer comfort evaluation (EN 16798-7 (BSI, 2019)).

From research projects on buildings in climates from UK, Scandinavia and France, it has been shown that even in warm summer conditions, use of air conditioning can be fully avoided through the use of natural ventilation, solar shading and automated control.

The efficiency of natural ventilation has been demonstrated both for its contribution to air renewal and summer cooling (Dupin *et al.*, 2014). Other alternative cooling solutions can be used to limit the use of active cooling like air conditioning. These solutions are usually using earth coupling (e.g. ground-to-air or ground-to-water heat exchanger) or evaporation (e.g. green roofs).

ENERGY GENERATION

1.8 New Technologies and Performance Characteristics

BIPV Glazing Technologies
There are several current and anticipated building-integrated photovoltaic (BIPV) technologies that allow for local power generation in windows and façades. These technologies may need to be incorporated into SAP11 to help deliver nearly zero energy residential buildings. BIPV is the integration of energy generating technology into the

building envelope itself, for example windows, roofs and walls, and can be opaque, semi-transparent, or transparent.

Technologies include ‘thick’ crystal products that include solar cells made from crystalline silicon either as single or poly-crystalline wafers.
BIPV technologies deliver about 108 - 129 watts per m² of PV array (under full sunlight).
‘Thin-film’ products typically incorporate very thin layers of photovoltaic-active material placed on a glass or metal substrate, which can deliver about 43-54 watts per m² of PV array area (under full sunlight).
T
he above technologies are described in more detail in the document, Glass BIPV Technologies - *Overview for Standard Assessment Procedure Industry Forum (SAPIF) - Rory Back, Incubation & Value-Added-Products Technical Manager, Advanced Technologist, NSG Group, 29th April 2019*.

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Appendix A: Overheating Context Document

Summary

Overheating in the indoor environment specifically in domestic homes, schools and healthcare settings has become of great concern to us in the UK. Overheating is a result of the heat gains associated with occupancy and solar heat gains trapped in the indoor environment which are exacerbated by the continuing rise in global average temperatures and the improved insulation and air tightness standards in building regulations. Although it is granted these improvements have been necessary for mitigating heat losses during the winter, they impacted the resilience of the building stock to hot weather events.
With the rise in the number of buildings that overheat and the rise in the number of associated deaths these contribute to, it is now crucial that buildings incorporate design methods and technologies that mitigate overheating.

Overview of SAP Appendix P

The Standard Assessment Procedure (SAP) (BRE 2012) is the Governments procedure for rating the energy performance of homes. Designers and developers in the UK need to show compliance with SAP for each of the domestic units they are designing. SAP is not a design tool, but rather a compliance tool and is designed to produce an energy rating for the unit under consideration. As such, the treatment of its thermal performance is under steady state conditions which utilises monthly mean air temperatures.

Appendix P of SAP provides a simplified check of whether the home will have an overheating problem. The monthly meant internal temperature thresholds in Appendix P are as follows:

- < 20.5°C then the risk of the home overheating is predicted to be 'Not significant',
- ≥ 20.5°C and < 22°C is equal to a 'Slight risk' in overheating,
- ≥ 22°C and < 23.5°C is equal to a 'Medium' risk in overheating,
- ≥ 23.5°C is equal to a 'High' risk in overheating.

The SAP methodology does not predict the severity of the overheating risk and the effectiveness of remedial solutions. The thermal performance of a building is a dynamic function of multiple variables and changes during the day. The use of a steady state approach that is using monthly average temperatures can mask severe hot events, their intensity and duration[57]. Furthermore, the whole house / volume approach fails to identify individual rooms at higher risk from overheating.

This was evidenced in the Energy Follow Up Survey carried out by BRE for DECC identified that 20% of 2616 houses surveyed "had difficulty in keeping one or more rooms cool during

[57] Zero Cabon Hub (2015) Defining Overheating: Evidence Review

summer months" and the average mean temperature for those households who reported an overheating issue related to a 'medium' overheating risk in the SAP Appendix P scale[58]. Currently calculations that address overheating in SAP Appendix P are not integral to the SAP calculation and it does not affect the overall SAP rating. Appendix P is viewed as 'too easy' by stake holders to pass as assumptions can be assumed in order to pass the assessment that are unrealistic such as windows open all the time which is unlikely due to security, air pollution and noise constraints in certain site contexts[59].

Site contexts are also not considered within the tool such as the additional heat burden properties within an urban heat island are under due to increased air temperatures, poor air quality, noise and security constraints.[60]

PRINCIPLES OF OVERHEATING

Overheating in buildings can be attributed to a single predominant factor or several combined factors. Excessive heat gains from external or internal sources of heat along with poorly specified or ineffective ventilation strategies are fundamental issues[61].

External Heat Gains

Sunlight and high external air temperatures contribute to overheating. Increasing global temperatures and frequent hot weather events due to global warming put buildings in the UK at increasing risk[62]. A well-insulated building fabric will prevent heat losses in winter but can also cause heat to be trapped in the building in summer.

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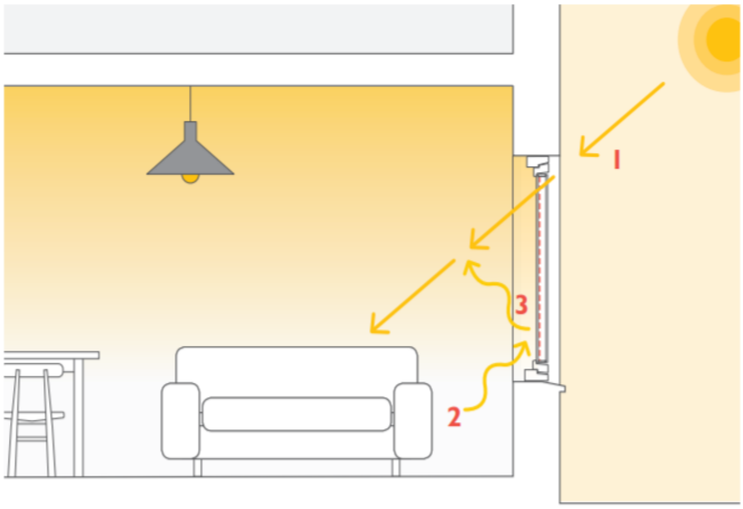
[58] Energy Follow-up Survey 2011 (2013). Report 7. Overheating and thermal comfort.
[59] Zero Carbon Hub (2015) Overheating in Homes: The Big Picture
[60] Amy-Alys Tillson, Tadj Oreszczyn & Jason Palmer (2013) Assessing impacts of summertime overheating: some adaptation strategies, Building Research & Information, 41:6, 652-661, DOI: 10.1080/09613218.2013.808864
[61] Understanding overheating – where to start: An introduction for house builders and designers
[62] UK Climate Change Risk Assessment 2017 Synthesis report: priorities for the next five years



1. Solar gains pass through the glass and heat the internal spaces.
2. These gains are absorbed by internal surfaces and emitted as heat.
3. In modern homes with double-glazed windows, this heat is retained well, especially if there is a low-e coating, and cannot easily dissipate through the highly insulated building fabric.

Figure 1.External Heat Gains (Image from [Understanding overheating – where to start: An introduction for house builders and designers])

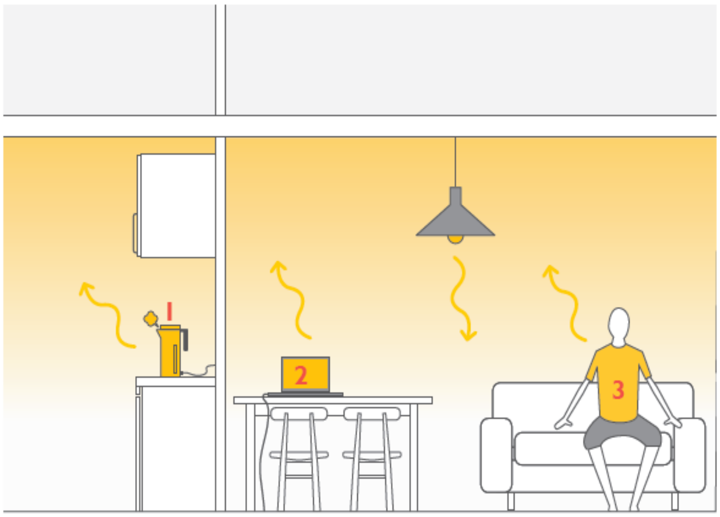
The sun's rays pass through the glazing as shortwave radiation or light, the rays hit objects in the room such as walls and furniture which absorb the radiation and re-radiate longwave radiation which emits heat within the building. If low e coatings have been applied to the glazing and there isn't an appropriate ventilation strategy in place the heat cannot escape. This same phenomenon happens in the atmosphere and is known as the 'Greenhouse effect' as it is most commonly replicated in greenhouses [63].

Internal Heat Gains

The heat generated from internal heat sources have been exacerbated due to increased insulation and air tightness measures in Building Regulations to improve energy efficiency. Sources of internal heat gains in domestic homes are as follows:

- Lighting – light fittings and plug in lamps
- Appliances – fridges, dishwashers, ovens, washing machines, televisions, laptops etc.
- Occupants – people generate heat and differing amounts of heat are generated depending on their 'metabolic rate' if they are sleeping or exercising
- Building Services – Hot water distribution and storage and mechanical ventilation systems.

[63] https://www.es-so-database.com/index.php/knowledge/low-energy



1. Occupants' activities: Cooking, bathing, showering all release heat into the dwelling.

2. Electrical appliances: Most electrical appliances give off heat when in use.

3. Occupants: People occupying a home all give off heat; the amount of heat is dependent on the level of their activity.

Figure 2.Internal Heat Gains (Image from Understanding overheating – where to start: An introduction for house builders and designers)

Appropriate Ventilation

Heat gain from internal and external sources can be reduced however they aren't eliminated. Ventilation strategies are needed to 'purge' heat from internal spaces. Internal warm air is replaced with external fresh air.

Ventilation is discussed in Approved Document Part L and F.

Part L aims to reduce the energy required for cooling and provides guidance for the reduction of solar gains (Criterion 3) through guidance on appropriate levels of solar gains and glazing characteristics. However, it does not address how the use of ventilation to dissipate or heat gains that are contributed from heat distribution systems[64].

Part F relates to fresh air for health and well-being and relies on purge ventilation to remove pollutants and odours from a dwelling it addresses this through stating that "there shall be adequate means of ventilation provided for people in the building"[8].

To reduce internal heat, the internal air volume needs to be replaced rapidly. Therefore, there needs to be adequate opening areas delivered by window, roof lights, door and/or ventilators. In urban areas this can be more problematic as occupant's health and comfort maybe compromised through proximity to external sources of air pollution and noise. Safety and security can also compromise methods of ventilation through the requirement for window restrictors and the lack of ability to ventilate rooms at night or when the building is unoccupied.

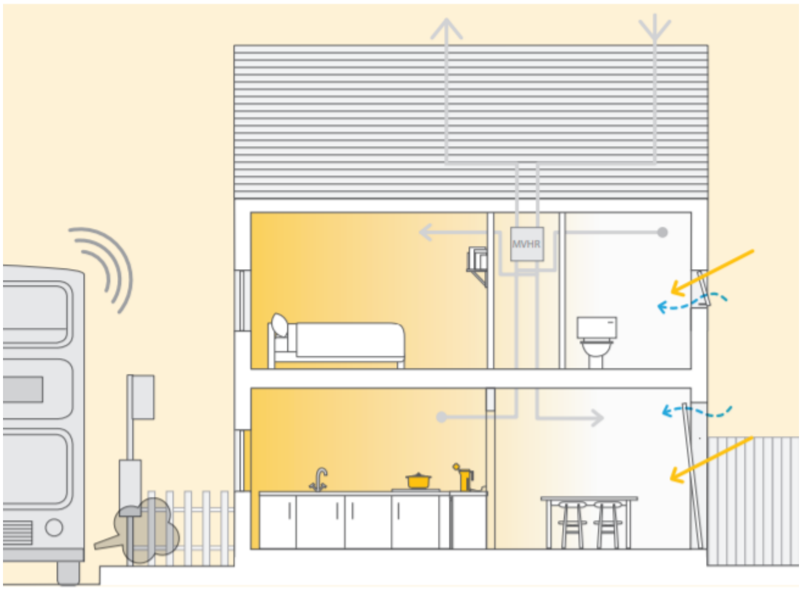


Figure 3. Ventilation Strategies (Image from Understanding overheating – where to start: An introduction for house builders and designers)

[64] CIBSE, Building Regulations Part L & F Briefing, November 2010

Background Ventilation:

Ventilation is supplied at a continuously low rate to dilute pollutants and provide fresh air. It may be provided by vents or grilles in windows and doors or ventilators in the wall.

Summer Background Ventilation:
Provisions should be made so that higher levels of ventilation can be provided in a secure manner during the warmer months. Typically, this type of ventilation is provided by opening windows and doors.

Purge Ventilation:
Purge ventilation should be provided, not only to remove pollutants, but also as a means of quickly expelling hot air.

FACTORS THAT INCREASE THE RISK OF OVERHEATING

Site Context

The likelihood of it overheating can be exasperated by the location of the building and its context:

- Proximity to external noise pollution (e.g. railways, main roads, airports).
- Proximity to mechanical services.
- Occupant perceptions of external air quality, pollution and/or odours.
- Security Issues

It is worth noting that the site context should also not be generalised as there can be significant as there can be large differences between the first floor and upper floors. For example, in a block of flats.

Urban Heat Island Effect

In urban areas, surface materials that are often used for landscaping and paving, and even the external finishes of surrounding buildings can affect the temperature of the surrounding air. Hard and dark coloured materials like concrete, brick and macadam have the tendency to absorb the sun's energy and heat generated during the day and re-radiate this at night. As a result of this, the night-time air temperature remains high. A night-time ventilation strategy depends on cooler night-time air temperatures and will become less effective if the surrounding air is warmed by these surfaces.

Figure 4. Urban Heat Island Climate (Image from [Understanding overheating – where to start: An introduction for house builders and designers](#))

Orientation

The orientation of a home is an important consideration. Solar gains can be taken advantage of in winter to reduce heating loads, but protection needs to be considered against unwanted solar gains that could contribute to overheating in the summer.

A home, when orientated with its main windows facing west will behave differently than if it were facing due south. A west-facing elevation may experience more unwanted solar gains from low-level sun in the evenings. A south-west facing elevation will also receive direct sunlight in the late afternoon when the ambient external temperature is at its highest, making the rooms on this elevation more prone to overheating. An appropriate approach would be to optimise the amount of glazing and position for each orientation but the potential for this may be limited in instances where standard home types are used.
Time of year should also be considered as winter months homes are exposed to more low altitude sun than in summer.

Building Design

The need to conserve energy in winter has resulted in Building Regulations being changed with the aim of improving the energy efficiency of new homes by encouraging higher standards of thermal mass, insulation and airtightness. The warming climate; improved thermal standards and poorly considered ventilation strategies have led to overheating in homes.

Designers should consider building orientation, size of glazing areas and types of construction (i.e avoid single aspect design) to avoid overheating. Design features and strategies should be considered at the design stage. Purge ventilation and solar shading must also be explained to occupants to ensure that these are used effectively.

Thermal Mass

Thermal mass refers to the ability of building materials to store and emit heat. If the design does not properly integrate thermal mass with adequate ventilation it may contribute to overheating within homes.

When the air within a space is warmed some building materials absorb the heat. As the space begins to cool down at night, this heat is then re-emitted into the space. Generally, heavier masonry-based materials have a higher thermal mass and absorb more heat than lighter timber-based and insulation materials and help to regulate diurnal temperatures. Homes constructed to recent standards of energy efficiency are well insulated and airtight to limit heat losses in the winter. In summer months, when the heat absorbed by building materials is re-emitted into the living spaces at night-time which can contribute to uncomfortably high internal temperatures. In homes with low thermal mass, there is a risk of overheating unless specific measures are undertaken to limit solar gains by shading and remove heat by adequate ventilation.

If the internal temperature is more constant (by appropriate absorption and release of heat) then this creates a more comfortable living environment which is more energy efficient as sources of space heating are run at more steady temperatures.

Service Design

Many overheating problems have been attributed to heat gain from consumer interface units (CIUs), hot water storage and distribution. Unless these components are very well insulated, they can become a source of unwanted internal heat gain in the summer as the demand for domestic hot water needs to be met throughout the year.

It is important to consider the effects of building services may be localised, for instance in a bedroom next to the water storage cylinder, or adjacent to a CIU where there is community heating. There is also the possibility that the ventilation system itself can become an unwanted source of heat. An MVHR system should be located within the insulated part of the home but its proximity to bedrooms should be limited where possible.

The distribution and storage systems for solar thermal panels need to also be well insulated as these will be circulating hot water throughout the summer months.
In apartments single-aspect apartment designs pose a greater risk particularly where community heating pipework is routed through corridors and common spaces due to inadequate ventilation. Since this pipework is constantly emitting heat, it can cause high

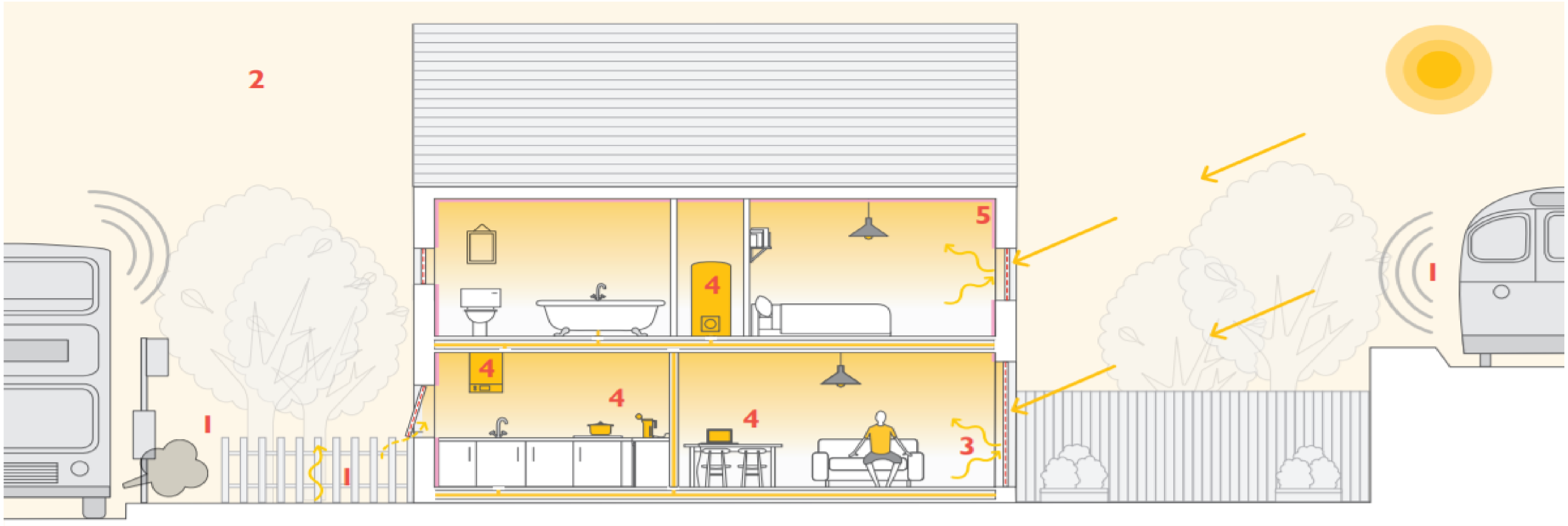
temperatures in these spaces, especially when there is insufficient ventilation. Even well-insulated heating systems will emit heat, albeit at a slower rate. Unless there is a strategy to remove this heat, it will be transferred from common areas into the adjacent apartments.

In apartment blocks where space and water heating are provided by a community heating system, the CIU is permanently charged with hot water all year round to meet the hot water demand. If this is not well insulated it may effectively emit heat like a radiator in the dwelling. It is often positioned in an unventilated cupboard or kitchen so heat transfers directly to the living spaces.

Restricted Ventilation Issues (Acoustics / Security/ Air Pollution)

Night-time ventilation becomes more important in hot weather but will only be achieved if secure ventilation is possible. In urban areas where the difference between daytime and night-time external temperatures may be small, the effectiveness of night ventilation will be reduced. There are also further challenges such as noise pollution and issues surrounding air pollution.

Cumulative Effects



1. Site context

External pollution, noise and excessive noise may prevent occupants from opening their windows. Surrounding hard surfaces will absorb heat and release this during the night.

2. External temperature
On a warm, still day when external temperatures are high, fresh air may not provide enough of a cooling effect to address overheating.

3. Solar gains
Double-glazed windows with a low-e coating prevent heat from escaping. Houses with unshaded west-facing glass will suffer from higher levels of solar gain in the warmer part of the day.

4. Internal gains
Electrical appliances, occupant activities such as cooking, and building services, e.g. boiler and hot water storage, all have the potential to radiate heat that may contribute significantly to the increasing internal temperatures.

5. Building design
Modern homes have increased levels of insulation and airtightness, resulting in more heat being retained within the homes. This means any built-up heat in the homes will have to be actively removed.

Consequences of Overheating

Increase to Cooling Energy Use

An International Energy Agency report in May 2018 from the showed that cooling energy use in buildings has doubled since 2000, from 3.6 EJ to 7 EJ, making it the fastest growing end-use in buildings, led by a combination of warmer temperatures and increased activity due to population and economic growth[65].

Energy use has declined over the last ten years. A survey in Nov. 2018 of 100 MP's revealed that only one realised that use of electricity had declined by 23% and gas by 17% between 2008 and 2016. This has been due to more energy efficient appliances yet even with that our supply of power in early December came exceedingly close to maximum capacity and the inevitability of power outages. The MP's survey shows a lack of appreciation of the fragility of our supply[66],[67].

A BRE study into energy use in the 10 years to 2016 for air-conditioning showed that it had been underestimated at 20TWh and was 29TWh an increase of 45%[68] which is equivalent to the 9TWh projected output of Hinckley Point.

Climate change will reduce energy demand for heating and increase energy demand for cooling in the residential and commercial sectors, as confirmed and quantified by the Intergovernmental Panel on Climate Change in 2014. IPCC estimates that global demand for residential air conditioning alone will rise from 300 TWh per year in the year 2000 to 4.000 TWh in 2050 and 10.000 TWh by 2100 with the majority of growth in developing countries. A detailed model projects that global residential energy demand for cooling will exceed that for heating by 2060[69].

An EU study confirms that in 2012 globally the refrigeration and air conditioning sectors were responsible for just over 7% of global greenhouse gas (GHG) emissions. This will rise to around 13% of global emissions by 2030, with almost exponential growth of demand for space cooling in some parts of the world. This directly impacts on carbon emissions through the release of refrigerants (CFCs, HCFCs, HFCs) which are potent greenhouse gases when released into the atmosphere.

New building codes with stricter requirements for the tightness of building envelopes also introduce significant cooling demands in summer. Unlike heating, cooling is today not

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65 https://www.iea.org/topics/energyefficiency/buildings/cooling/
66 https://eciu.net/press-releases/2018/energy-bills-are-falling-and-mps-are-in-the-dark
67 https://www.simplyswitch.com/mps-arent-aware-energy-bills-falling/
68 https://www.bre.co.uk/filelibrary/pdf/projects/aircon-energy-use/DECC-AC-summary-page.pdf
69 https://www.giz.de/expertise/downloads/GIZ_GreenCoolingInitiative_Siegele.pdf

considered a necessity throughout Europe, but only a comfort factor in some Member States. Therefore, cooling supplies are almost always lower than full cooling demands, since all cooling demands are not met and, in some Member States, most consumers accept uncomfortably higher indoor temperatures during warm summers[70].

Impact on Occupants Health and Well-being

The experience in USA & Australia where air-con is more prevalent is that it is the poor that suffer by being unable to afford the running cost and this is particularly applicable to the vulnerable elderly[71].

A report confirms that maintaining an adequate level of indoor temperature improves European citizens' wellbeing. Evidence suggests that households in energy poverty are more likely to suffer from a higher rate of excess winter deaths, morbidity issues, mental health problems and social isolation. Negative impacts on health are also apparent as a result of excess heat during summertime. Affordable heat and cool is even more important for those who spend more time in their houses for reasons of bad health, disability, age or lack of employment[72].

- End of Appendix 8d -

[70] https://ec.europa.eu/transparency/regdoc/rep/1/2016/EN/1-2016-51-EN-F1-1.PDF
[71] Gertrud Hatvani-Kovacs et al. Heat stress-resistant building design in the Australian context, *Energy and Buildings* (2017). DOI: 10.1016/j.enbuild.2017.10.025
[72] Insight_E (2015) 'Energy poverty and vulnerable consumers in the energy sector across the EU: analysis of policies and measures'. Available at: http://ec.europa.eu/energy/en/news/energy-poverty-may-affect-nearly-11eu-population

Appendix 8e

Group 5 Ventilation and Indoor Air Quality

Adrian Regueria-Lopez, Nick Howlett

BEAMA and RVA

Final Report 09th of April 2020

SAPIF Group Objectives:

1. To establish the state of the art, sources of information and basic explanations of the technologies/systems expected to be mature in the mod 2020's
2. To propose some modeling criteria for the performance of the technologies and secondly how compliance could be judged at both product and dwelling level.

If government decides to include recognition of the technology or system in SAP11, to work with government and the SAP contractor to develop the details

Members of the industry working group 5.
Aereco, Airflow, Atamate, BEAMA, FETA (Residential Ventilation Association RVA), Greenwood/Zehnder, Nuaire, Titon, Volution, West Energy.

Output of WG 5
List of new technologies to be included in SAP 11

1. Ventilation in SAP

The group analysed how ventilation is covered in SAP to understand where improvement could be made.

Ventilation is covered in terms of the following aspects:

Air permeability (especially relevant for mechanical ventilation and heat recovery)

Energy efficiency and energy use

In-use factors (relating to insulation, ducting, installation…)

Ventilation system:

Mechanical extract ventilation h)	$IUF \times SFP \times 1.22 \times V$
Balanced whole house mechanical ventilation fans h)	$IUF \times SFP \times 2.44 \times n_{mech} \times V$
Positive input ventilation (from loft space)	0
Positive input ventilation (from outside) h)	$IUF \times SFP \times 1.22 \times V$

Figure 1. Energy calculation for various ventilation systems, which is calculated as the product of on In-use factors, the specific fan power of the unit, the density of the air and the volume of the dwelling.

It should be noted that System 1 and PIV (if it is in the loft), do not result in any energy consumption according to SAP.

Ventilation controls are not covered and do not play a role in determining the efficiency of the ventilation system. This is in clear contrast to the approach in SAP for other technologies, such as heating or domestic hot water.

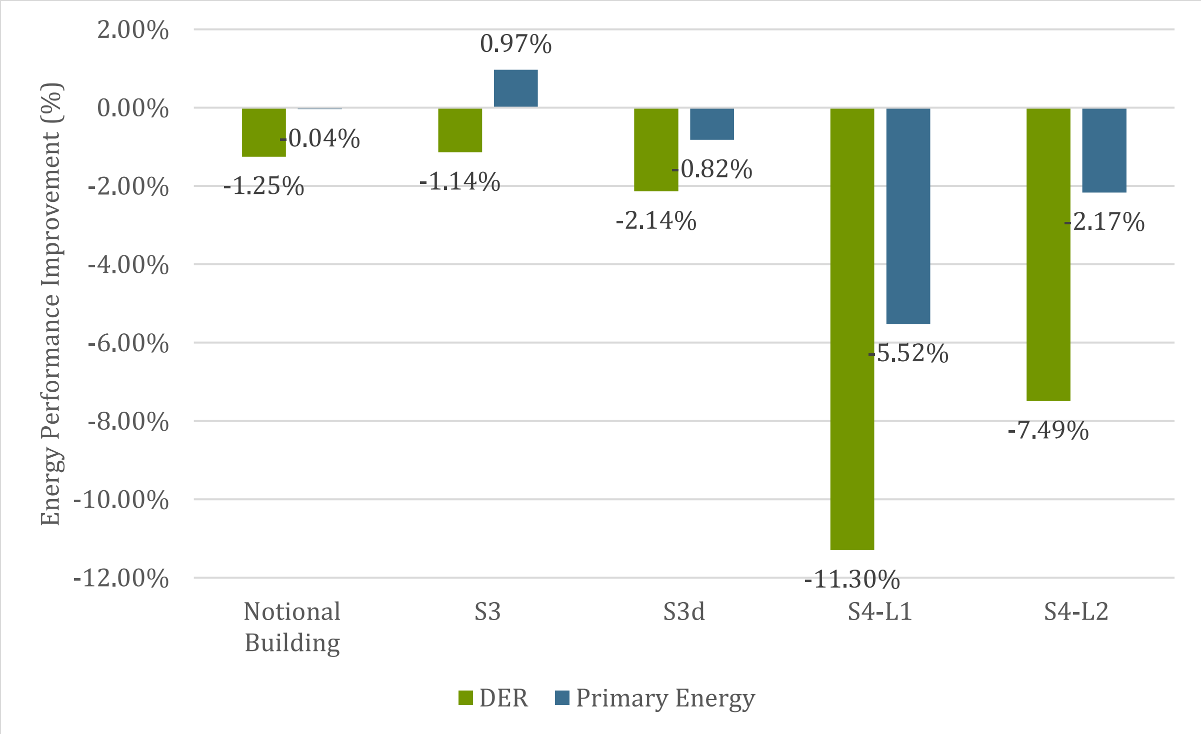
This suggests that there is scope for introducing ventilation controls, which all ventilation units already have and are already considered in other pieces of UK and EU legislation (e.g. Building Regulations, Ecodesign).

2. Indoor Air Quality and Energy Efficiency in SAP and Part L

The group produced a number of SAP assessments to understand the impact of different ventilation systems in the overall energy performance of the dwelling. This is important to understand the scope of energy savings that ventilation controls could introduce in the current framework.

To than end, BEAMA carried out a number of scenarios in two dwellings where the energy performance with various ventilation systems is compared to that of System 1 (the system in the notional dwelling). The specification of the baseline dwelling is that of the notional dwelling in SAP 10.1, as per the below:

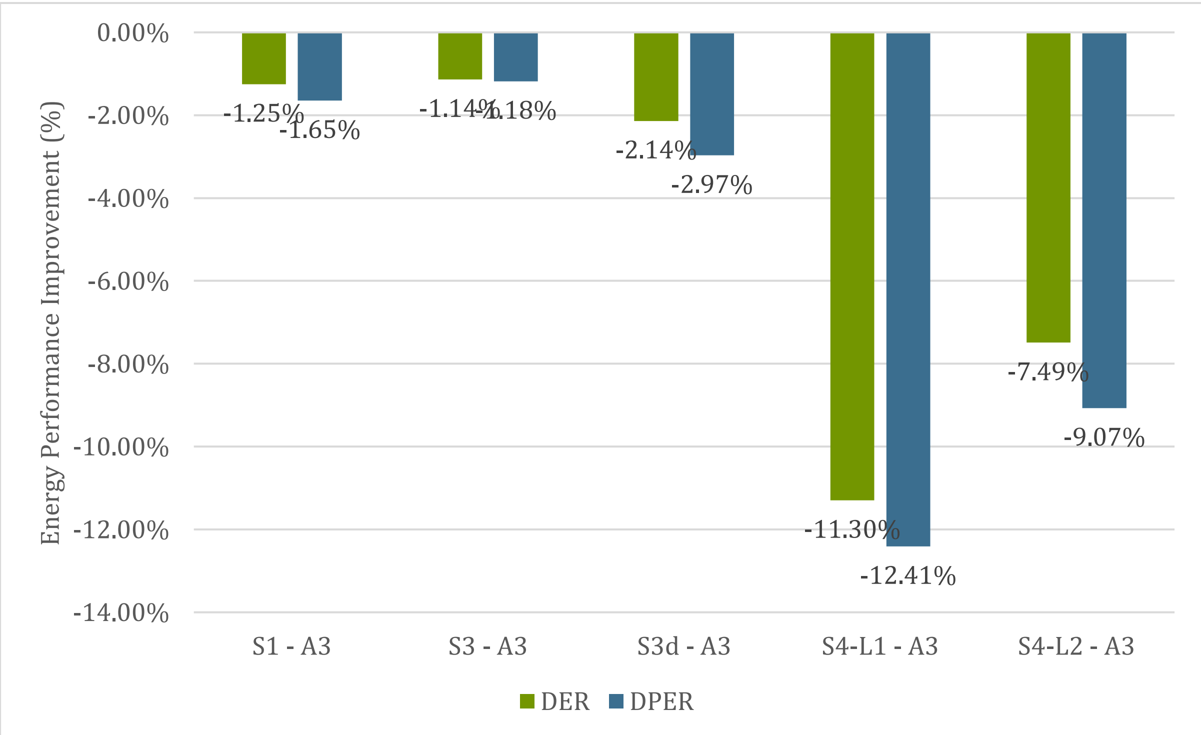
- Detached House in Southern England
- TFA: 70 m^2
- Openings: 14.33 m^2
- Notional building fabric
- Gas Condensing Boiler
- 2 x Warm Water Heat Recovery (Shower)
  - kW PV
- Airtightness: 5 m^3/m^2h

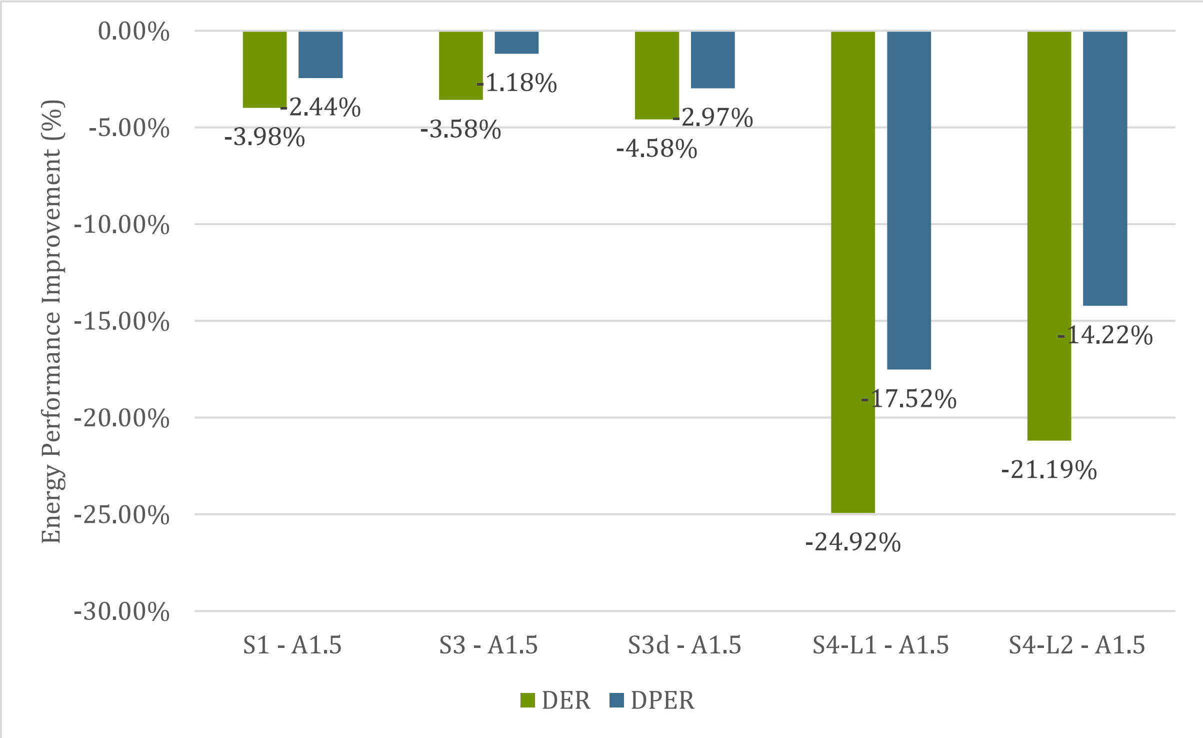


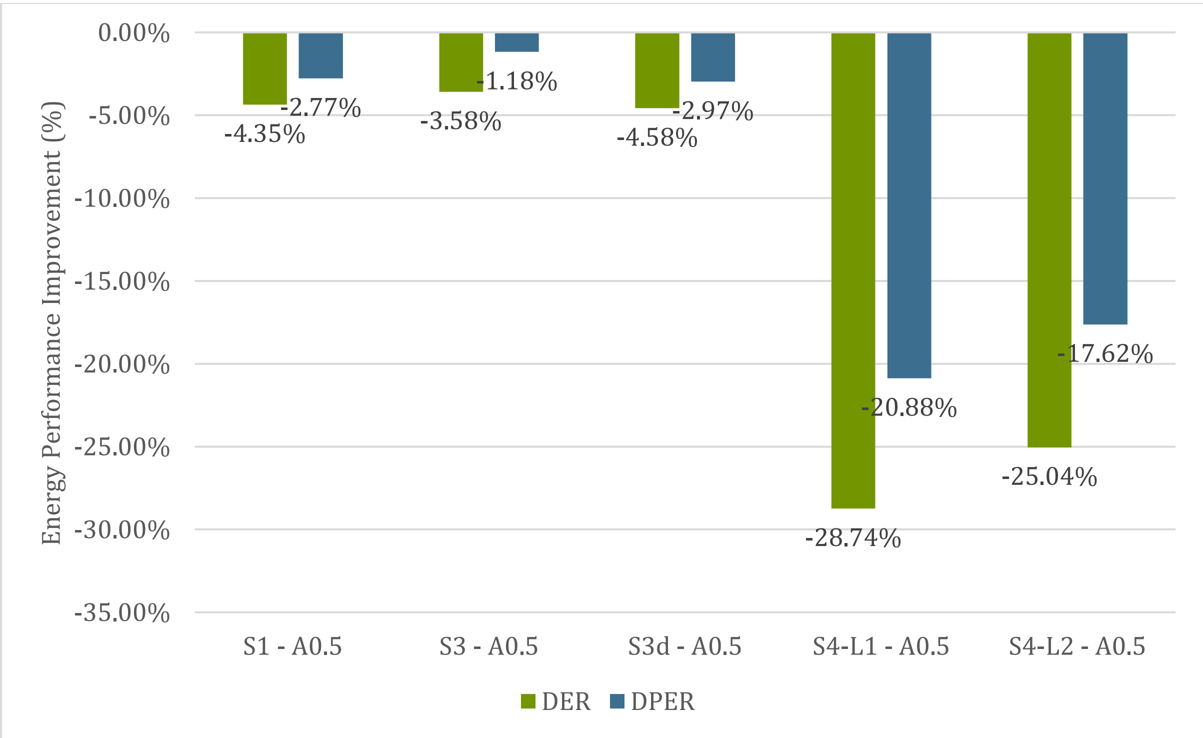
It can be seen that continuous ventilation, except MVHR due to its heat recovery element, does not receive any significant benefits in SAP, with a full central mechanical ventilation system only being 0.91% and 0.78% in terms of carbon emissions and primary energy, respectively, better than the notional dwelling (System 1).

Similar scenarios were carried out for airtightness levels of 3 m^3/m^2h, 1.5 m^3/m^2h and 0.5 m^3/m^2h.

This leaves very little room for controls to provide an attractive energy saving, if it is considered that the absolute minimum would be zero energy consumption.



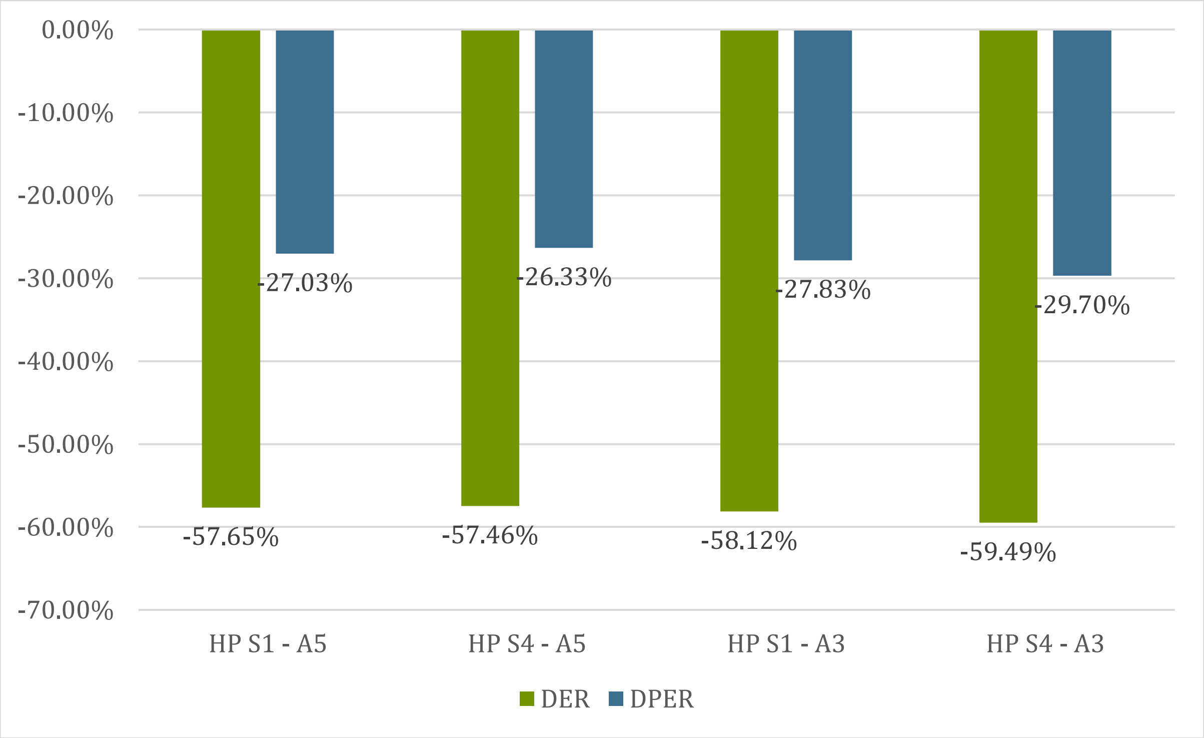


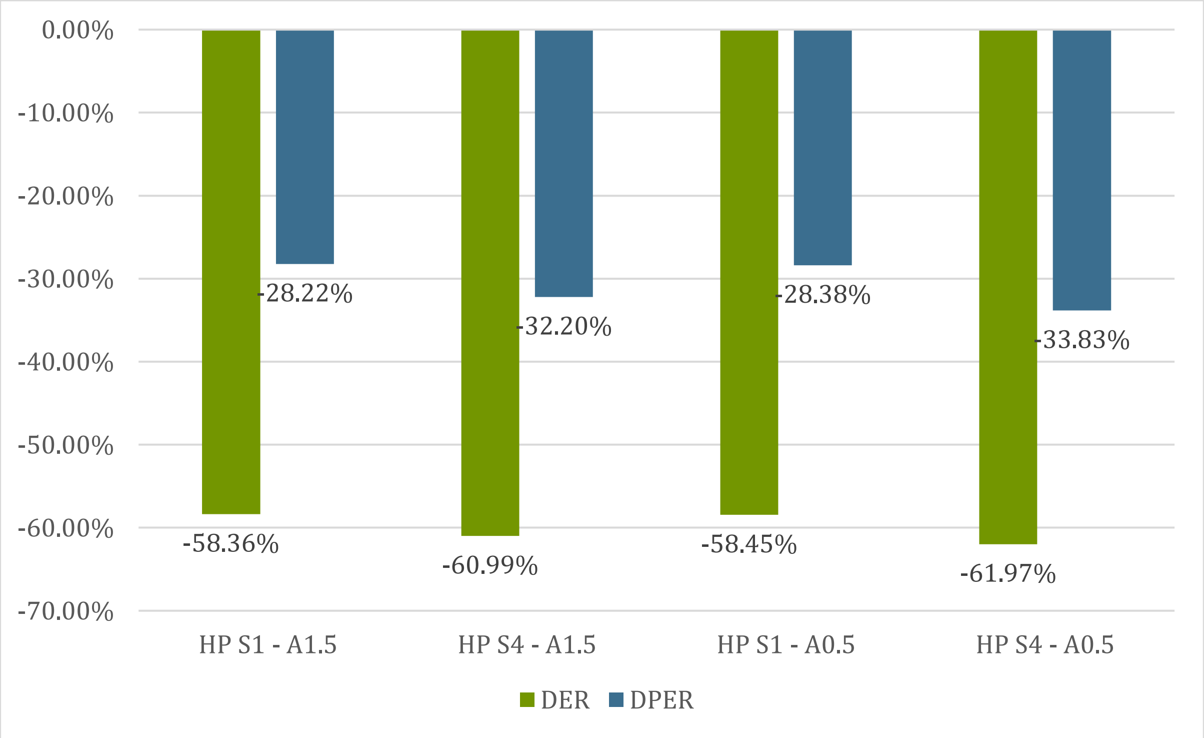


It was found that mechanical extract ventilation was not encouraged by SAP at any level of airtightness, given the very similar levels of performance between System 3 (both centralised and decentralised) and System 1.

It is noted that the Government is planning to cap the benefits from reduced airtightness (below 3 m^3/m^2h) for dwellings with System 1. However, comparing the performance from System 1 at an airtightness of 3 m^3/m^2h and System 3 at an airtightness of 3 m^3/m^2h, it is easy to see that the performance improvement is still only 2.33% and -0.47% for centralised systems and 3.33% and 1.32% for decentralised systems, in terms of carbon emissions and primary energy, respectively. In addition, the BRE are planning to introduce stricter testing requirements for decentralised mechanical extract ventilation, which are likely to result in a reduction of their performance in SAP.

Lastly, the same dwelling was modelled with an air-source heat pump (from the SAP Tables) and System 4 (mechanical heat recovery ventilation), at different levels of airtightness, against System 1.





It can clearly be seen that mechanical ventilation with heat recovery only receives a modest benefit in relation to System 1, due to the low-carbon nature of heat pumps

The conclusions drawn from this analysis are listed below:

- The lack of potential energy savings from introducing ventilation controls in SAP is unlikely to be attractive enough for manufacturers.
- The fact that SAP is based on minimum ventilation rates and that intermittent extract ventilation is modelled as not consuming any energy discourages the uptake of continuous ventilation (unless with heat recovery).
- There is a lack of consideration of indoor air quality in SAP. It should be noted that the Commission's EPBD guidance recommends, in Annex I (Point 1, second paragraph) that the "methodology applied for the determination of the energy performance of a building to be transparent and open to innovation. This requirement applies to all elements that are part of the calculation, including: (f) consideration of national indoor air quality and comfort levels in the calculation of energy performance for different building types.
- The cap on energy savings for intermittent extract and background ventilators is welcome, although it is not likely to provide enough encouragement for continuous ventilation systems even at very low levels of airtightness.
- The analysis also shows the important role that MVHR can play in low-carbon new-build homes with gas boilers, with carbon reductions of up to 28.74%, for an MVHR system at very low airtightness levels and best-case scenario regarding SAP in-use factors. Dwellings with heat pumps installed, however, will not see major benefits due to the inclusion of mechanical ventilation with heat recovery. It should also be noted that this analysis used the specification of the notional building, and results will be different for different specifications used in reality.
- Due to this, it is appropriate that the Government is proposing in the Future Homes Standard Consultation that continuous systems are specified by default for design airtightness levels lower than $5m^3/m^2/h$, when tested at 50Pa.

3. Control Standards

The group looked at existing standards as potential ways for introducing controls in SAP. However, while there are a variety of product and installation standards (EN 13141 series and EN 13142), there are not specific control standards which can be used to provide compliance, which is a major barrier which is Ecodesign Regulation No. 1253/2014 (Ventilation Units) recognises controls through "in use" factors, which feed into the overall energy consumption of the ventilation unit, based on EN 13142 factors. The equation and the factors applied are below:

$$SEC = t_a \cdot pef \cdot q_{net} \cdot MISC \cdot CTRL^x \cdot SPI - t_h \cdot \Delta T_h \cdot \eta_h^{-1} \cdot c_{air} \cdot (q_{ref} - q_{net} \cdot CTRL \cdot MISC \cdot (1 - \eta_t)) + Q_{defr}$$

ventilation control	CTRL
Manual control (no DCV)	**1**
Clock control (no DCV)	**0,95**
Central demand control	**0,85**
Local demand control	**0,65**

It is noted that this approach does not take into account the quality within a specific type of controls, but just awards better CTRL factors for more localised controls.

It is noted that this approach does not take into account the quality within a specific type of controls, but just awards better CTRL factors for more localised controls.

EN 13142 and Ecodesign Regulation No. 1253/2014 are currently being updated and this is subject to change.

The group concluded that, in light of this, industry would likely need to create an assessment platform and standard for basic augmented controls, potentially accredited by a third-party body. This would require that attractive energy savings were available, which would likely need to require a change in SAP's ventilation methodology, particularly regarding the use of minimum ventilation rates as the reference point.

4. Ventilation Controls: State of the art

The group put together a list of current ventilation controls, in relation to the units they're linked to and the types of inputs they are based on. It was decided to provide a general description of the types of controls rather than provide specific examples of technologies. These are provided in Appendix I.

5. Other

5.1 Compliance and Policing

The group discussed the importance of enforcement and policing to improve compliance in ventilation installations. Industry is aware of these issues, as highlighted in a recent Government report, and has significantly contributed to the development of the NICEIC ventilation training scheme.

In addition, industry is urging the Government to create a better framework for the notification process to Building Control of ventilation installations, such as that used in Part P for electrical installations. BEAMA would be happy to engage further on this topic.

Ultimately, the enforcement of Building Regulations is crucial for compliance within SAP, and can result in considerable energy savings (badly commissioned fans are likely to consume more energy; in addition, fans which are badly commissioned might not fulfil their function adequately, but still consume energy).

5.2 PCDB Technology Recognition Process

The group welcomed the clarification of the stages for the recognition of technology. The group do not consider this to be the correct methodology in the future for our specific industry. We suggest that although it has been, and is very helpful the assessment process for ventilation in its current format will stifle ventilation innovation in the future. Which has stagnated for several years, in terms of bringing on new technology to market. There is no incentive for manufacturers or house builders to adopt further innovative technologies, other than those already in the PCDB of SAP.

The ventilation industry's product innovation activity is based on our expertise in product design, the tangible conditions for the successful potential of newly designed product and the subsequent manufacturing of them. Whereas the existing assessment process for new technology is academically lead requiring 'university level' research papers as evidence and potentially with supporting field data too. This is before even commencing the long and costly approval process and not notwithstanding the product development costs. At present, potential indoor air quality improvements is subordinated to energy savings by SAP. This situation will stifle innovation improvements in IAQ because there is no genuinely open discussion or thought about how to bridge the gap outlined above. Therefore we strongly suggest that future energy calculations, recognised within SAP11, are revised and based on potential Indoor Air Quality benefits.

We recognise that this is difficult given the current regulatory and assessment frame work. SAP is energy based but actually prevents innovation in IAQ technology and it's time to evolve from its current form. We propose that changes within Approved Document F of the Building Regulations and Part L, are discussed allowing the Government to create the conditions which allow for better IAQ arising from innovation. This means allowing the variation from minimum to increased levels of ventilation rates in ADF that lead to improvements in indoor air quality via the purpose provided continuous ventilation. (It is important to note that this is not via demand control below the minimum regulated ventilation requirements.) This could potentially be done by encouraging product innovation that improves indoor air quality by being sympathetic to it in ADL and SAP 11. The approach would provide firm guidelines for the ventilation ranges applicable for varying the ventilation to accommodate different life styles, changes in occupant numbers and specifically when dwellings change hands over long periods of time. This would help with take up of innovative controls. We would be pleased to discuss this further in due course.

Appendix I

SAPIF IAQ & Ventilation - List of Ventilation Control Types				
No.	**Categories of control/optimisation/visualisation**	**Control Parameter**	**Description**	**Impact on standard SAP profile/assumptions**
1	Manual on/off controls	Switch, cord	Manual input by the user to turn unit on or off. This does not include fans isolation as a form of control. Typically used for intermittent fans in wet rooms	None
2	Manual boost controls (single or multi-speed)	Switch, cord	Manual input by the user to increase minimum ventilation rate to boost	As SAP currently only models minimum ventilation rates, the effect of these controls would not have an impact in the energy use by the ventilation unit. In reality, these controls can save energy by reducing the amount of time that ventilation units are unnecessarily running at higher rates than the background ventilation rate, particularly in wintertime (when heated air is extracted from the property).
3	Manual boost controls (single or multi-speed) with timer	Switch, cord	Manual input by the user to increase minimum ventilation rate to boost, limited to a certain amount of time	
4	Fixed Boost Controls	A control parameter indicative of occupancy or demand	A control parameter triggered by user demand/occupancy automatically increases ventilation rate to the maximum	
5	Variable Boost	A control parameter indicative of occupancy or demand	A control parameter triggered by user demand/occupancy automatically increases ventilation rate in a variable manner in accordance with the control parameter.	
6	Background ventilation controls	A control parameter indicative of occupancy or demand. humidity/pressure controls, bidirectional control	A control parameter triggered by user demand/occupancy automatically regulates the intake or output of air through the background ventilator	

Table 1. Types of ventilation control and their control parameters and description.

SAPIF IAQ & Ventilation - List of Ventilation Control Types									
No.	**Categories of control/optimisation/visualisation**	**Relative Humidity**	**CO2**	**VOCs (gases)**	**Presence/Occupancy**	**Switch/Light sensor**	**Current/Temperature/Pressure**	**Manual Input**	**Systems**
1	Manual on/off controls					`			System 1
2	Manual boost controls (single or multi-speed)								All Systems
3	Manual boost controls (single or multi-speed) with timer								All Systems
4	Fixed Boost Controls								All Systems
5	Variable Boost								All Systems
6	Background ventilation controls								System 1, 2 and 3

Table 2. Compatibility of ventilation controls and types of input (green = compatible, orange = non-compatible)

Ventilation Controls - Types of Input		
Parameter	**Description**	**Indicative of occupancy or demand?**
Manual Input	A direct signal from the occupant directly turns on or increases the ventilation rate.	
Relative Humidity	Relative humidity is a measure of the partial pressure of water vapour to the equilibrium vapour pressure of water at a given temperature, and is a measure of moisture relative to a certain pressure and temperature. It is used as a metric to regulate ventilation rates based on the moisture generated in household activities such as cooking or showering, mainly in wet rooms.	
CO_2	The concentration levels of CO2 and can be used as an indicator of indoor air quality. Therefore, ventilation rates can be regulated based on the measured CO2 concentration levels generated by the occupants or by other activities (i.e. cooking).	
VOCs (gases)	Volatile Organic Compounds are organic chemicals which have a high vapor pressure (i.e. volatile) and they are generated from building materials, furniture, office equipment and consumer products. Some of them are dangerous to human health, and therefore VOC sensors can be used to determine when ventilation rates need to be increased or decreased. Contrary to humidity or carbon dioxide, VOCs are not caused by human activity.	
Presence/Occupancy	Occupancy detection sensors can be used to determine how to regulate ventilation rates, as many of the pollutants that are typically removed by ventilation systems are caused by human activity.	
Switch/Light sensor	In rooms with no windows, a switch or light sensor can be used as a proxy for occupancy, and therefore as a way to determine when ventilation rates need to be increased.	
Current/Temperature/Pressure	In certain circumstances, these parameters can be used to determine how to regulate ventilation rates. For example, a current sensor can be used in electric hobs to determine when the kitchen extract fan should be turned on or taken to boost. Similarly, a temperature sensor that measured a shower hot water pipe could be used to determine when a bathroom fan should be turned on. Pressure differences between the inside and the outside can also be used to regulate background ventilators.	

Table 3. List and description of inputs parameters and whether they are indicative of occupancy of demand (green = compatible, orange = non-compatible)

- End of Appendix 8e -

Appendix 8f – SAPSIG

SAPSIG meeting – FINAL DRAFT
Thursday 6th February 2020
Attendees:
Adam Tilford, Ashely Bateson, Neil Cutland, Richard Fitton, Simon Lannon and Stuart Fairlie
Peter Noyce (BEIS)
John Henderson (JT) (BRE)
John Tebbit (JTe) (chair) and Nick Booth (RDL)
Apologies
Kevin Lomas, Martin Searle, Bob Lowe and Tone Langengen

Purpose of the meeting
To hear SAPSIG's views on the strategic issues around the development of SAP11 so as to inform any future developer of SAP11 as well as government.

Method
A discussion document (attached as Annex A, written by JTe and JH) which set out some of the questions that have emerged during the SAPIF work on future technologies, was circulated to SAPSIG members prior to the meeting. SAPSIG members were encouraged to consider the questions posed but also to bring their own questions and ideas to the meeting.

The meeting was run as an open discussion and minutes have not been taken. Rather, these notes should be taken as a synthesis of the various views expressed. For clarity and ease of reading, some of the notes of the discussion have been re-ordered and grouped with other similar content.

Key points

1. There are pros and cons for moving SAP11 from a monthly average to a dynamic (half hour demand) model and such a move should be considered. Alternatively, there is a case for reducing SAP back to a much simpler steady-state model and to use mainstream dynamic simulations for the more dynamic features that will become increasingly necessary in future energy scenarios.
2. Whilst assessment of overheating risk could be part of SAP it is unlikely that SAP could become the tool that allows designers to fully assess and mitigate overheating.
3. There does not appear to be any fundamental problem for SAP to model new shared technologies such as communal energy storage or load shifting. SAP already does similar things.
4. Until there is certainty that the as-built data being entered into SAP accurately reflects what is actually physically built, the 'Performance gap' will remain. It would arguably be a waste of public money to further develop SAP without sorting this fundamental problem.

5. Consideration needs to be given to a better coordination and funding of research, possibly via a contribution from industry via an EPC levy.
6. The governance and operation of SAPSIG needs reviewing, given the voluntary nature of the group and the increasing complexity of the questions being put to it.

Notes of the meeting

1 Metrics

The meeting started with a discussion on which metrics SAP11 and Part L could use in order to achieve net zero energy buildings. A number of organisations (including CIBSE, UKGBC, RIBA, LETI) now think using kWh/m2/yr (measured at the meter) is the best metric for energy efficiency because it encourages fabric efficiency equally to other technologies. Other metrics tend to have unintended consequences and don't minimise fabric losses[73].

However, it was recognised that a kWh of electricity is 4-5 times the price of a kWh of gas. Other outcomes (running costs, CO2) not minimised by kWh/m2/yr metric are also important, so perhaps having more than one metric is a sensible way to meet multiple goals – but this probably should include a specific fabric energy efficiency metric such as the current DFEE.

Equally, it was recognised that SAP can provide any/all of these metrics, so this is an objective-driven policy choice. Provided SAP is a good model of reality, it has the ability to encourage the desired outcomes given appropriate targets within Part L and other regulation. It was noted that if low CO2 is the priority, the current best solution – as noted in the current Part L consultation - looks like efficiency of fabric + heat pump + PVs; this also gives low running costs and low energy demand. However capital cost could be an issue.

2 Dynamic versus monthly average model

There are various reasons for considering a move to a half hourly SAP model as opposed to the current monthly average model. One is that with heating and DHW being driven by government policy towards an electric model, peak loads might become more critical for the wider electricity supply network. Another is that it is difficult to adequately model the performance of some combinations of technologies without considering time of day issues explicitly (e.g. utilisation of battery storage). Also, if SAP were to include a more sophisticated overheating facility, then a dynamic model may be needed.

The group (including BEIS) recognised that moving to a half-hourly (or similar) SAP model by 2025 would be challenging. But, there is a European Standard for an hourly method which could form the basis of this, so we would not be starting from scratch – it would be a case of creating a UK implementation of this. Potentially this new modelling core could become common to domestic and non-domestic assessments.

There was discussion around whether it would be sensible to use this new more complex model only for new homes, but continue to use the simpler model for existing stock. If so, arrangements would be needed for the transition for when a new building became an existing building later.

[73] TECHNICAL NOTE: kWh measured at the meter is termed "Delivered energy". This is not the same as Part L's proposed metric of "Primary energy", which is measured at the 'well-head'.

A contrary opinion was that there is a desirable continuity, with practical advantages, of the same model being used for all assessments. The inputs can be much simpler for existing buildings, while still using the more complicated back end, and using suitable inference, as RdSAP does today.

It was noted that if the original SAP data were to be stored along with any changes to the building post-construction, potentially the more detailed model could continue to be used for future assessments. This has advantages such as continuing to fully recognise the technologies in the dwelling and hence giving a more realistic EPC. This could be seen as a development of the BREL proposal in the Part L consultation as well as in line with the Digital Built Britain policy. To clarify, this would mean all homes built post 2025 would always use the original full detailed SAP data, modified as necessary for changes in the dwelling, for first build and in subsequent 'existing stock' situations.

The other potential driver for a half hourly or dynamic model was the issue of overheating. Overheating was acknowledged as a significant issue in new homes, especially flats. It was felt that even a more complicated SAP model is unlikely to be able to assess overheating well, so it should not be modelled physically in SAP. However, there could be a simple tick list type risk assessment that could be implemented via SAP software and by SAP assessors, which could filter which dwellings needed a more detailed assessment (likely to be primarily flats).

Therefore, SAP could be part of a mechanism for providing a 'Red, Amber, Green' style warning of the risk of overheating. Data such as location, aspect, building typology, whether on a heat network and so forth could be put into a matrix to give such a rating. If a dwelling was at risk of overheating then there should be used other more specific tools for fully understanding the risk and mitigating it. The Zero Carbon Hub carried out significant work on overheating and much of that remains pertinent today.

It was noted that the Passivhaus Planning Package (PHPP) model was widely seen as being a better predictor of overheating. There might be some effect from a better quality of build e.g. no uninsulated heating pipes running through the building but this is not clear. Given that PHPP is essentially a monthly average model, albeit with more detailed data entry than SAP, there did not appear to be an overwhelming case for SAP11 to be a dynamic model for overheating.

Regarding peak loads, perhaps other regulations or policy levers would be more effective than SAP and Part L in mitigating the peaks? There was a wider issue here, in not overcomplicating SAP for relatively little benefit.

There was a brief discussion on the question as to whether SAP could be drastically simplified to say a Target U-value approach for fabric and a list of efficiency requirements for services. SAPSIG was clear that interactions between fabric and services as well as between services meant that such an approach is probably not viable.

3 System boundaries

A number of the technologies being put forward by the SAPIF Working Groups are shared between dwellings rather than being confined to a single dwelling. For example, heat storage might be a large unit shared between a cluster of homes or a shared ground loop of pipes with hot, cold and ambient water, from which individual homes exchanged energy.

Regarding system boundary issues associated such systems/infrastructure shared between multiple dwellings, the group didn't consider this to be a major problem for SAP to handle. There are already precedents (heat networks, shared PV systems and even normal grid tariffs) where suitable assumptions are made – and similar solutions can be used for other systems.

There might be regulatory issues in terms of ownership, compliance, scope of the Building Act but these are not SAP issues.

4 Load shifting and occupant behaviour

The issue of batteries (including vehicle-to-grid) was raised in relation to load balancing. It was felt this could largely be handled like other user-behaviour issues (e.g. hot water demand) – as long as typical user behaviour is known the model can make those assumptions for rating purposes (even if particular occupants behave very differently).

However, might it be useful to provide to householders a version of SAP where they could experiment by tailoring the occupancy parameters to their own to create a model able to give them more suitable recommendations and advice? The previous Green Deal Occupancy Assessment was mentioned as a method suitable for underpinning such a tool. SMETER-type products could also be important in this context.

5 Quality of data entered into SAP

There was considerable discussion on the quality of inputs into SAP calculations. It was noted that the 'Performance gap', so well documented by Zero Carbon Hub and others, was seen far less in homes using PHPP and the Passivhaus QA system. Given that PHPP uses the same building physics and algorithms, the obvious conclusion is that the difference in performance is in the difference between the scheme requirements of SAP and PHPP to ensure accurate data. PHPP's requirements encompass certification of product performance for example, but probably the most important issue is rigorously monitoring the build process in order to ensure that the data entered into PHPP is an accurate representation of the as-built home.

SAPSIG strongly felt that spending lots of time and money undertaking research to make the SAP methodology more sophisticated would be greatly undermined unless confidence in the modelling inputs could be raised. There may still be benefits in allowing promising new technologies to be recognised, but it was a strong opinion of the group that much more should be done to ensure inputs represent the building correctly. 'Performance gap' issues clearly remain (as well documented in work by

ZCH and others). For instance, ZCH reports showed that SAP data errors resulted in some cases in a 25% overstatement of performance.

At present SAP assessors are not in a position to check what they are told, i.e. they will generally take the house builder's word for what is actually built on site, as opposed to the specification/drawings provided to the SAP Assessor. The nature of the construction industry is that on-site design changes are often made, which are not always conveyed to the SAP Assessor. There is also the issue of non-delivery of the 'as-designed' SAP calculations and Predictive Energy Assessments (PEAs). The 'as designed' SAP calculations can be done by anyone, with no requirement for any skill or knowledge and they are not typically enforced or requested.

We would advocate to simply use the already competent persons (OCDEAs), who should submit (lodge) 'as designed' calculations, as well as 'as-built' calculations to show compliance. This is a very simple move that quality assures this particular part of the process.

The requirements are for:

- 'As designed' calculations and a Predictive Energy Assessment (PEA), this is to enable marketing of the energy efficiency of the home off plan.
- 'As built' calculations and an EPC.

The 'as designed' calculations and PEAs are not lodged or submitted to Accreditation Schemes – therefore, we don't know the quality of these. The 'as built' calculations and EPCs are submitted/lodged to Accreditation Schemes – therefore, we do know the quality of these ones.

Anecdotally, it is believed that what occurs is that the 'as designed' calculation may be done by 'X' (an unaccredited person) and who may also do the 'as built' calculations. As soon as the builder finds out he needs an EPC, 'X' can't do it (as s/he can't lodge to an Accreditation Scheme). The builder then contacts a trained OCDEA who starts again, and often the house may not comply, and it's physically built and the builder just wants an EPC for sign off.

By requiring both 'as designed' and 'as built' calculations and PEAs to be lodged by OCDEAs, this will obviate the above problem.

It was noted that builders' desires to keep costs down, means that SAP Assessors are not able to universally provide a service that records 'as built' inputs into SAP. An EPC generated by SAP software based on the incorrect specification, even leaving aside quality of build, will be misleading to the dwelling occupant about the energy performance of the building. This is clearly a consumer protection issue, as well as a failure to achieve the desired (government) policy outcome.

Two possible process changes were discussed:

1. Give the assessor greater authority and responsibility (with correspondingly higher fees) to attend site to check that the specification being given to go into SAP matches what is being built and/or;

2. Require the developer to sign-off the specification and create a realistic possibility for discrepancies to be detected and a requirement to remedy the specification if it is wrong. Providing the specification of the house to the householder would be one way of creating that. The BREL proposal in Part L starts to move along this path.

6 New products, research and innovation

In discussions around the new product recognition process, there was mostly agreement that the existing system works for new products. The recent work to make Appendix Q more understandable was noted.

However, it was also noted that this creates a system with uneven funding, where the methodology for new products is better funded and researched (by the product industry in general) than work on existing products or researching and updating assumptions at the core of the SAP model. The group noted that the assumptions on DHW use were old *(mostly dating from 2008, but some as far back as the 1980s)* which was possibly a significant risk given that DHW in new homes is increasingly becoming the dominant energy use. More generally, it would be good practice to record the dates of all the assumptions in SAP so as to be able to plan reviews. It was further noted that there were other 'systems' in SAP that are based upon old assumptions.

More widely, research on dwelling energy efficiency seems to be uncoordinated, with piecemeal studies into particular aspects undertaken from time to time. SAPSIG, or a group set-up specifically for the task, could be convened to provide guidance to government (also perhaps research funding bodies) on areas in need of research. Comparing this to known areas of work being undertaken to identify gaps could provide this missing coordination.

It was recognised that such a group/process might generate a wish list for research not achievable under the existing SAP budget, so there was some discussion of how this might be better funded. Suggestions included the introduction of a charge of, say, £5-10 on each EPC created to provide a central fund to be used for research to improve the quality of EPCs. Industry funding is always likely to be focussed on products of interest to the particular industry providing the funding, so this was thought unlikely to solve the problems.

SAPSIG issues

There is a feeling amongst SAPSIG members that the increasing technical complexity and specialisation of queries that they are asked to consider is pushing members beyond what they can reasonably be expected to deal with, both on knowledge and time, given that the members are unpaid volunteers.

It was suggested that BEIS should consider funding technical experts for particularly complex or specialised areas and use SAPSIG as interrogators of those experts.

Annex A
SAPSIG discussion paper v1

Purpose of paper

This meeting of SAPSIG is to hear the views of members on what they think are the big issues and questions around SAP11. For instance, how will it fit with wider government policy; what is the scope of SAP – dwelling, building, development; is SAP too complex or too simplistic.

This paper starts to set out some questions that are being thrown up by the SAP Industry Forum (SAPIF) working groups in their work to identify mainstream technologies for the mid 2020s and the methodologies for modelling them, as well as broader questions that the authors have picked up in their discussions. Please note that the authors are trying hard not to answer the questions! The questions listed are designed to provoke discussion, but SAPSIG members should not feel limited to considering the areas identified.

There are no correct or incorrect answers and we are not seeking agreement or consensus amongst SAPSIG members, just thoughts and ideas. We will try to record the views of SAPSIG members but will not be doing this verbatim or as formal minutes.

As ever, nothing in this paper nor any exclusion from it should be taken as indicative of government policy.

Introduction

The SAPIF is working towards the finalising of its report on likely mainstream technologies by the time SAP 11 is in use and methodologies and modelling criteria for said technologies. The final report, including an overview document from RDL and BRE, is due to be presented to BEIS at the end of March 2020.

SAPIF has set up five working groups (WGs) as below:

- WG1 Domestic Hot Water, Heating and 1-day HW storage
- WG2 Smart Controls, Technologies and Tariffs
- WG3 Home Energy Storage (heat and electricity)
- WG4 Overheating including prevention and cooling
- WG5 Ventilation and IAQ

The intention is to submit the reports from these WGs as-is without editing from the BRE/RDL team so as to minimise information loss.

This paper sets out some issues raised by the WGs' work as well as broader issues from the BRE/RDL. There may well be further issues from SAPSIG members and these are welcome. We would like to keep away from detailed technical discussions on specific technologies, except perhaps where they are illustrative of a broad issue, instead focussing more on SAPSIG members' thoughts on the strategic issues for SAP11.

Issues

These are loosely arranged into groups for ease of reference. Please do not feel constrained by them.

Scope/boundaries of SAP

- It appears likely that multiple dwellings will share facilities, particularly storage, which may be outside the boundary of the properties. For example a battery for electricity or a heat store. A consistent way of dealing with such facilities is needed. Legal advice may be needed on how Part L and SAP deal with facilities outside the property boundaries.
- It is recognised that energy supply systems such as the gas grid, electricity grid and heat networks are already 'beyond the dwelling' but is there a fundamental difference when the energy flow becomes two way and/or involves storage for the dwelling?
- Shared ground loops with hot, cold and possibly ambient temperature water may become more widespread. Dwellings could put energy into these loops and take it out via heat pumps. Is this load shifting or is it just the same as a normal GSHP? Does it also raise issues about where the physical boundaries are drawn for the dwelling in terms of Building Regulations?

Storage and load shifting

- Some facilities such as electric vehicles with vehicle to home or vehicle to grid (and vice versa) capabilities are mobile, such that a change of occupant may result in different (or no) storage capacities and charging rates.
- If SAP and EPCs are to give estimated costs of running the dwelling, how are tariffs and load shifting (in terms of timing, carbon intensity) going to be treated in SAP11. Or should they even be covered? This covers load shifting within a 24-hour period but there may also be inter-seasonal storage.

Average or peak energy demand

- With government policy pushing heating towards being electric, peak half hour demand rather than average annual use may be more critical. Should SAP11 address this and if so, any thoughts on how that could shape the design of SAP11?

Compliance and actual performance

- Compliance is now at point of sale or handover, so SAP cannot take account of actual performance for that particular dwelling. Is there any technology or system on the horizon that could change this?

Complexity versus simplicity

- If dwellings are going to have fabric efficiencies similar to Passive House from 2025 onwards, could the fabric be taken as a given and SAP concern itself only with services? Perhaps a list of services and minimum efficiencies?
- DHW is likely to be the dominant energy use but demand is extremely variable between ostensibly similar dwellings and occupants. Should we try to get a better handle on the use of DHW or are there other approaches that could be considered?
- Overheating requirements are likely to be proposed to be a separate standalone item for Part L 2020. For SAP11 what are the benefits and challenges for integrating it into SAP for Part L2025?

Compliance criteria

- At present we have primary energy, cost, CO2 as the compliance criteria with a range of limits on fabric and services, e.g. backstop U-values, efficiency requirements for services. What criteria could be considered in the future that SAP11 would have to supply and any thoughts on practicalities? Note that we will not necessarily be bound by EU requirements.

Visibility of technical solutions for supply chain

- The house building industry and its supply chain will have to make significant changes to be able to meet the Future Homes Standard in 2025. Any change in SAP creates new winners and losers in terms of technical solutions for Part L. Are there any ways to mitigate this so as to reduce the risks for the supply chain in particular of finding SAP10 solutions no longer viable under SAP11?

- End of Appendix 8f -

Appendix 8g – Devolved Administration Interviews

Notes from discussions with Building Standards Branch, Northern Ireland re SAP11

Background

A telephone discussion was held on Wednesday 4th March. The objective was for John Tebbit as chair of SAPIF to hear initial thoughts from John Burke, Building Standards Branch on the SAPIF work on SAP11 and to note his views. This note is John Tebbit's understanding of the discussion.

Present:

John Burke	Building Standards Branch, Northern Ireland Government
John Tebbit	Robust Details, Chair of SAPIF

Summary of discussion

It was noted that SAP10 and Part L are at present focussed on operational energy use. It is likely that by the time SAP11 comes into use there will be demand for whole life carbon analysis to be carried out. Possibly not as a compliance check but certainly by some clients. In addition, there will be demand for real life operational data to be fed back and compared with/update the original as-built data.

This reinforces the need for the data structure of SAP11 to be designed from the ground up to support interoperability of data. At the simplest level it means consistency of naming and measurement conventions. At a more complex level, it requires transparent and standardised data structures so that data can easily be moved into other systems such as DSM. For Northern Ireland, the ability to move data in between SAP, EPCs and POINTER systems (used by NI government for property registrations) would be hugely valuable. It would be extremely beneficial to have common Unique Reference Numbers for properties across various systems or robust links to ensure correct identification. Northern Ireland has domestic rates rather than the Council Tax and these consistent property references should help progress new policies for NI such as MEES and or even a rates adjustment depending on EPC rating.

The ability to re-use original SAP data for future EPCs is crucial. It will allow more sophisticated newer homes to retain their EPC rating rather than risk down grading due to RdSAP over simplifying.

Whilst the ability to localise SAP further is nominally attractive e.g. a Northern Ireland rather than UK grid electricity carbon intensity, the reality is that apparently small and simple changes could result in amounts of analysis work to implement and then an ongoing commitment from the point at which local factors are adopted to re-assess subsequent developments at the local level. For this reason, and without ongoing NI specific research funding to maintain such localised input, there would need to be a high degree of caution and demonstrable major benefit, if any localisation of SAP was to be considered in NI.

Notes from discussions with Building Standards Scotland re SAP11

Background

The meeting was held in Edinburgh on Tuesday March 3rd. The objective was for John Tebbit as chair of SAPIF to hear initial thoughts from Building Standards Scotland (BSS) on the SAPIF work on SAP11 and to note BSS's views. This note is John Tebbit's understanding of the discussion.

Present:

Linda Stewart	BSS
Steven Scott	BSS
Craig Donnelly	BSS
John Tebbit	Robust Details, Chair of SAPIF

Summary of discussion

Overall SAP already does what is required in policy terms and likely policies. There may be areas where more localisation could be useful. For example, tweaking of Appendix T (recommended improvements) would help deliver more Scottish-centric solutions and changes to the value of dwelling generated electricity might be considered due to Scottish grid conditions.

However, the underlying SAP engine and specification are seen as sound.
We discussed the SAPSIG view that on balance there is not a case for SAP to become a dynamic model for compliance purposes. However, there may be some merit in DSMs or more bespoke behaviour scenarios for operational analysis. *Post meeting note: This emphasises the need for SAP data to be interoperable with other systems and models.*

Verification of SAP data is an issue both as designed and as built. There is ongoing work in Scotland on improving verification beyond just Section 6/ Part L. The Hackitt review and its themes are relevant across the UK.

Notes from discussions with Building Regulations, Welsh Government re SAP11

Background
A telephone discussion was held on Monday 16th March. The objective was for John Tebbit as chair of SAPIF to hear initial thoughts from Paul Keepins, Building Standards Technical Officer on the SAPIF work on SAP11 and to note his views. This note is John Tebbit's understanding of the discussion.

Present:

Paul Keepins	Building Regulations, Planning Directorate, Welsh Government
John Tebbit	Robust Details, Chair of SAPIF

Summary of discussion
JT explained the background although PK was already aware of the DA interviews. PK noted that much of the policy development that might use EPCs was by others so he couldn't comment on that. However the ability to re-use original SAP data for future EPCs would be very useful. As commented on by other DAs, this would allow more sophisticated newer homes to retain their EPC rating rather than risk down grading due to RdSAP over simplifying.

The growing dominance of energy use for DHW was discussed. It was recognised that the data on and modelling of DHW usage was based on relatively old research, which should be reviewed and possibly updated.

PK noted that the just ended Welsh Part L consultation had Waste Water Heat Recovery systems in the notional dwelling. There was possibly some merit in a more detailed look at hot water pipes, the length of time to get hot water at the tap and then the wasted hot water left in the pipes. PK noted that the extra detail could get quite complicated.

There was discussion about MVHR and installation, commissioning and maintenance issues but this was felt to be peripheral to SAP.

Overall, there was not anything in particular at this time that PK felt to be missing from SAP and the SAPIF WG reports.

- End of Appendix 8g -

- End of report -