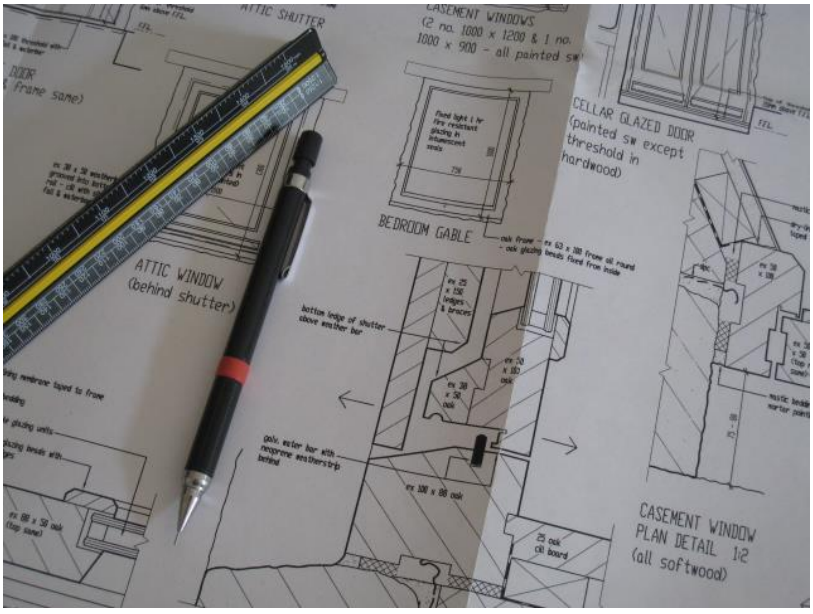
energy saving experts



SAP: The Essential Guide
For Dwelling Designers And Architects
By Mike Andrews

'The overall aim is to give the dwelling designer a better understanding of what SAP is, how it is used to demonstrate compliance with Building Regulations Part L1A, the information required by an assessor to complete the calculations, and which of the many input fields has the greatest impact on the overall results'

SAP (Standard Assessment Procedure): The Essential Guide For Dwelling Designers And Architects

How it works, what input is required, and what makes a difference to achieving a pass

Contents

Preface

I decided to write this book firstly to help dwelling designers, be they architects, contractors or self-builders, to understand what SAP is, what it does and doesn't do, and what information is required for the calculation. Secondly, I aim to explain which parts of this input information have the most influence on the end result, and why. I have completed hundreds of SAP assessments and lost count of the times a dwelling designer has met the minimum requirements of Part L, yet their dwelling fails, and the designer is left wondering how that could be. This book will provide the answers.

I've also taken the unusual step of presenting the book backwards. Everyone is busy, and I for one don't like having to read my way through a whole book full of detail to get to the point right at the end. Therefore, after a brief introduction, I've written what really matters first – in a nutshell, so to speak. After that, if the reader wants to go into the details – and I suggest you do for a full understanding – it's all there in Parts Two and Three.

Special thanks to Ben Smith at Batterham Matthews Architects for his input, and thanks also to Batterham Matthews Architects, and Favonius Architects for the use of their excellent drawings.

Feedback is always welcome. If you want to contact me, please do so at:
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Mike Andrews

Introduction

To complete a SAP assessment and eventual Energy Performance Certificate (EPC) there are many input fields requiring information about the proposed dwelling that require entering into the chosen software. Some of these place the dwelling in a context, for example its address and built form, whilst others account for the performance and have a fundamental impact on the result. The aim of this book is to demonstrate the whole SAP input process and, by doing so, to demonstrate what factors affect the final result, and by how much. It also aims to show the process and information required by the dwelling designer for each input field in the software.

In summary, the overall aim is to give the dwelling designer a better understanding of what SAP is, how it is used to demonstrate compliance with Building Regulations Part L1A, the information required by an assessor to complete the calculations, and which of the many input fields have the greatest impact on the overall results.

The book has been written by an accredited SAP assessor and EPC provider, an On Construction Domestic Energy Assessor (OCDEA) with information compiled from official SAP documentation, and the author's own knowledge and experience from completing many SAP assessments over several years. A list of sources is provided at the end of the book.

The book is written in three parts: Part One outlines what the SAP process is, and what is usually needed to gain a pass. Part Two looks in detail at the SAP input fields, what information is required and the effect this has on the overall SAP result. Part Three looks beyond the SAP calculation and focuses on what information is required to satisfy Building Regulations Part L1A.

Unlike many technical books, this one aims to be different by giving the reader most of the answers at the beginning, without the need to read the whole thing! You can find these in Part One.

However, to really understand how the process works, I would suggest at least reading each Section in Part Two. To help focus on the important issues, each one is summarised with the key points. If you only read one thing, go straight for these summaries at the end of each Section. They are highlighted in blue.

Part Two is for those who already have an awareness of SAP and have worked with an assessor in gaining Building Regulations for Part L1A. So this section allows these readers to 'dive right in' and understand why some dwellings pass ok, whilst others are more of a challenge.

For the more technical or curious reader, Part Three is written in a similar way to our previous documents on Part L1B and L2A, providing as it does the background information and knowledge about how the software and the calculation methodology work in relation to one another.

One of the reasons for writing this book is to show the effect that individual input can have on the results. However, the calculation works as a whole, and although there is a Model/Notional Dwelling in the calculation that must be equalled or bettered, and there are minimum back-stop values in the Building Regulations that must be equalled or bettered, the calculation process is flexible, and deliberately so. Therefore, whilst some performance values may be better than the Model/Notional Dwelling, some could be a good deal worse. If the resulting CO_2 emissions and fabric energy efficiency targets are achieved, that's fine. Therefore, although I have taken the various inputs into the SAP calculation separately, to show how these affect the result, in reality they all work together to achieve that final result.

At the time of writing (Winter 2016/2017), there are some changes planned to Part L after a Government Consultation. These are not mentioned in this book as they are still to be decided. However, once the changes are known, this book will be updated accordingly. Any purchasers of the original will be offered a replacement for a nominal fee.

PART ONE
SAP and Building Regulations, SAP Software and Compliance With Part L1A

There are various SAP software packages offered by each of the accreditation schemes, for example NHER Plan Assessor, Stroma FSAP and Elmhurst Design SAP. They are all formatted differently but the input required and the outputs gained are all the same. This ensures there is a consistency in the reporting, irrespective of which software is used, or which scheme.

For the purposes of this document, I have used NHER Plan Assessor as the main test software, checking for consistency using the Stroma FSAP software.

The latest edition of the SAP software (SAP 2012) is formatted to produce compliance documents for Building Regulations Part L1A in England 2013. It can also be used to demonstrate compliance for Part L1A Wales (2014), and Section 6 (2015) in Scotland. For Northern Ireland SAP 2009 is used. In total there are a minimum of approximately 140 input fields, and that's with only one heat loss floor, wall, roof and one opening for a basic two-bedroom, end-of-terrace dwelling! This number can easily be doubled. It's important to know, therefore, which of these input fields the dwelling designer must provide to the assessor, which can be influenced, and which have the greatest impact on the final SAP result. This section of the document will explain that.

Full details of the SAP calculation and procedure are available in the following document:

The Government's Standard Assessment Procedure for Energy Rating of Dwellings 2012 Edition.

Where SAP Default Values are quoted throughout this book, full details can be found in the above. It is freely available to download from:
https://www.bre.co.uk/sap2012/page.jsp?id=2759#

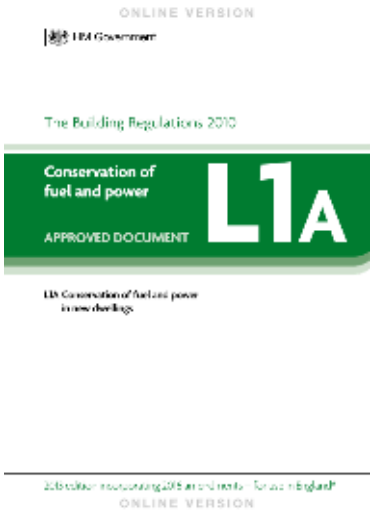
Conservation of Fuel and Power

The *requirement* of Building Regulations Part L 2010 (with later amendments) is that reasonable provision shall be made for the conservation of heat and power by limiting heat gains and losses through the building fabric and services, by providing energy-efficient services and controls, and by providing the building's owner with sufficient information for efficient operation and maintenance.

The regulations are divided into L1 for dwellings, and L2 for non-dwellings. Furthermore, L1A is for new dwellings, L1B for existing dwellings and, likewise, L2A for new non-dwellings, L2B for existing non-dwellings.

The above Regulations are also slightly different for England, Wales, Scotland and Northern Ireland and each have their own Approved Documents. This book will focus on England only. The Welsh Regulations have many similarities to England, whilst Scotland and Northern Ireland differ in their approach. However, the SAP compliance software, the information required for the calculation, and the process followed are the same for all countries and, once a postcode is entered into the software, the appropriate Regulations are automatically applied to the calculation.

Part L Approved Documents: Dwellings



Approved Document L1A: Conservation of fuel and power (New dwellings); (2013 edition for use in England)

Approved Document L1A: Conservation of fuel and power (New dwellings); (2014 edition for use in Wales)

In Scotland, Regulations apply as follows:

- Technical Handbooks 2015 Domestic – Energy

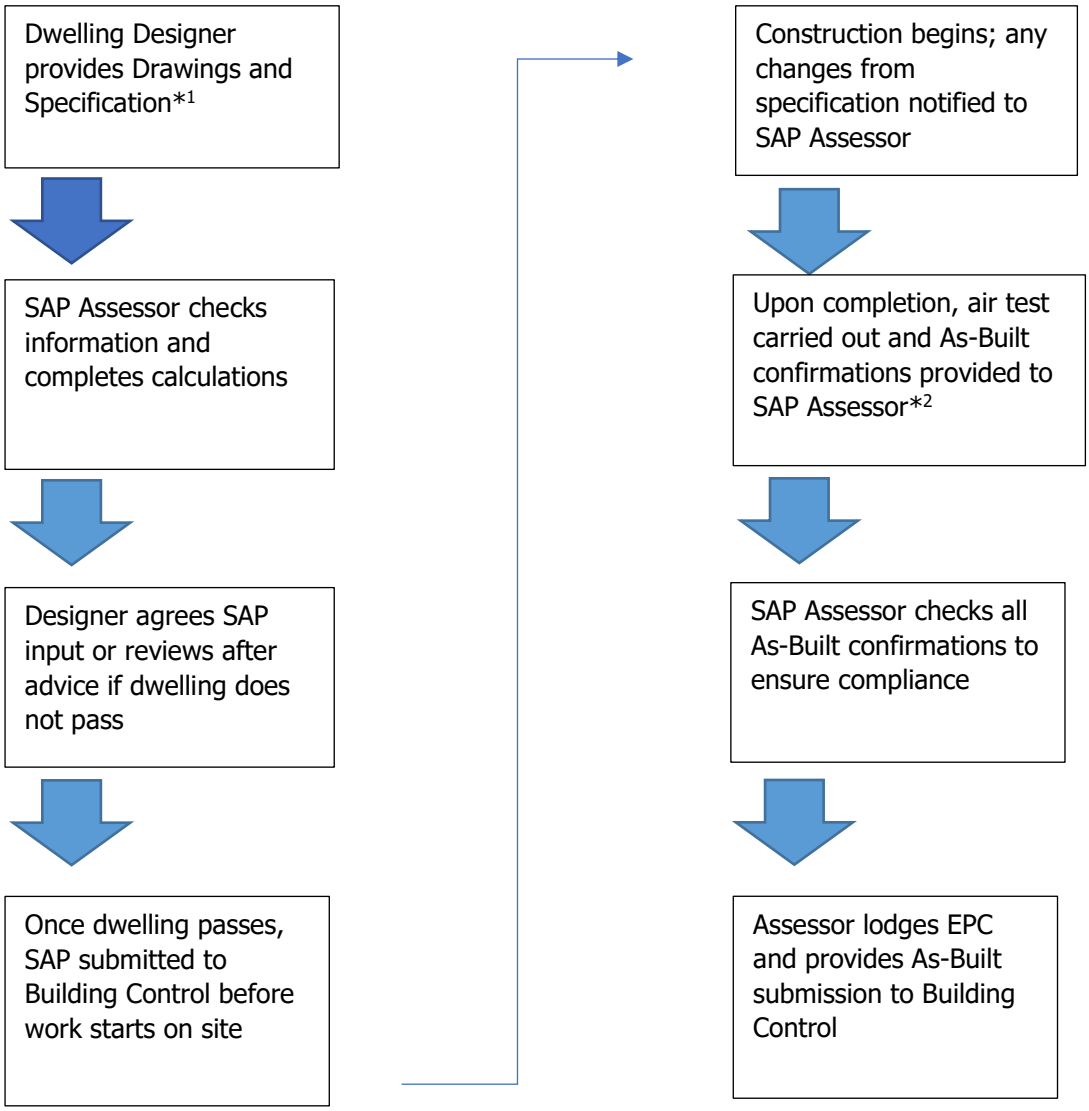
In Northern Ireland, Regulations apply as follows:

- Technical Booklet F1 Conservation of fuel and power in Dwellings 2012

Second Tier Supporting Documents

Domestic Building Services Compliance Guide 2013 – England

SAP – Simplified Process Map



*1 See Appendix 4: New Build Checklist – to be used at Design Stage to provide the required information for the SAP Calculation.

*2 See Appendix 5: As-Built SAP Checklist – to be used upon completion of the build for confirmations required for Building Control and Energy Performance Certificate.

New Dwellings: TER/DER and TFEE/DFEE

For new dwellings, compliance must be demonstrated by SAP calculations comparing CO_2 emissions (kg CO_2/m^2/year) expressed as a Dwelling Emission Rate (DER) against a Target Emission Rate (TER). The DER must be equal to or lower than the TER. The DER is derived from all the SAP input.

The TER is calculated using a Notional Dwelling based on a Model Dwelling contained in Appendix R of SAP 2012. The calculation is shown below:

TER2013 = CH x FF + CPF + CL
CH = carbon from space and hot water heating
CL = carbon from internal lighting
CPF = carbon from pumps and fans
FF = fuel factor

The TER is estimated using a parallel SAP calculation based on the same dimensions as the proposed dwelling but using a set of reference values for the building fabric and the heating systems, etc.

These reference values include U-Values for the main building elements, specific psi values for all junctions, a gas-fired boiler with radiators (with SEDBUK 89.5%), natural ventilation with extract fans, an air permeability of 5 m^3/hm^2 at 50 Pa and 100% of fixed lighting outlets being low-energy fittings.

It is this parallel dwelling from Appendix R of the SAP 2012 document that is also the Model Dwelling found in Section 5: Model Designs from Approved Document L1A 2013 Edition.

There is also a requirement that the fabric energy efficiency, expressed as a Dwelling Fabric Energy Efficiency (DFEE), is lower than the Target Fabric Energy Efficiency (TFEE). The DFEE is derived from the dwelling size and shape, U-Values, Air Permeability, Thermal Bridging, Thermal Mass and the number of Extract Fans and Open Flues present, and is a calculation that works out the demand energy requirement, both heating, and cooling, if present (kWh/m^2/year). The TFEE rate is calculated by determining the fabric energy efficiency from a Notional Dwelling constructed according to the reference values in Table 1, below. The fabric energy efficiency is then multiplied by a factor of 1.15 (15%) to give the TFEE rate. This 15% reduction was derived from a higher FEE target originally set by the Government but was relaxed for the introduction of Part L 2013.

The TER and TFEE are figures automatically generated by the compliance software, and are based on performance values set in the calculation, but using the same building shape, size and orientation as the proposed dwelling.

Both DER/TER and DFEE/TFEE are calculated at both design stage and again once the building is completed.

The dwelling must also achieve minimum standards of thermal efficiency in both the construction element U-Values and air tightness, the risk of overheating in

summer must be avoided by careful design of ventilation, glazing orientation and shading, and the construction should be designed to meet minimum standards to avoid significant Thermal Bridging. Therefore, a fabric-first approach should be adopted.

Building Services should meet the minimum requirements for efficiency and use of appropriate controls as determined in the Domestic Building Services Guide.

A strategic approach should be adopted where the aim is to reduce energy demands overall, meet the remaining energy demand with high-efficiency systems that are well controlled, and then consider the use of renewable energy to offset the energy demand. A renewable energy system should not be used as a basis for a poorly insulated building.

To help gain compliance, if the maximum U-Value targets, minimum system efficiencies etc, as stated in Part L Approved Documents, were followed, it's highly unlikely that the dwelling would pass. This is because the Notional or Model Dwelling, the one forming the TER and TFEE, is using values that are much lower than those in the Part L Approved documents. See Table 1, below.

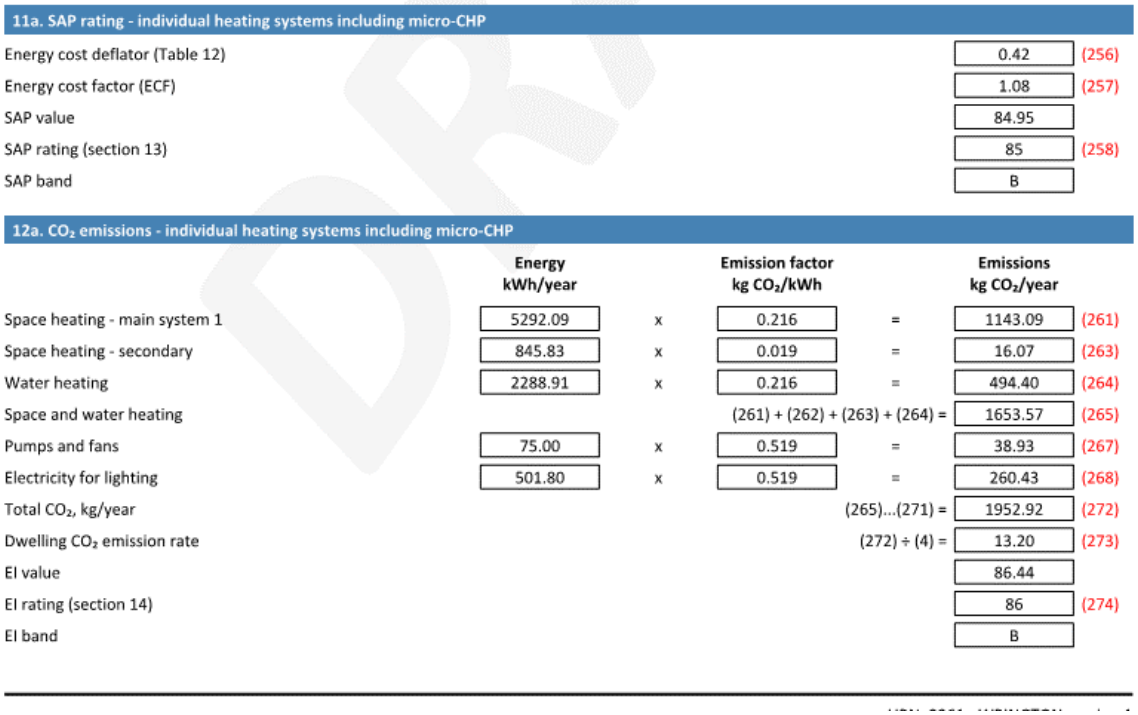
SAP Rating

Where does the SAP rating fit in?

The SAP rating is a way of comparing dwellings, 1 being the lowest (like a tent), and 100+ being the best (Zero Carbon). The average dwelling in the UK is around 50; most new builds are up in the 80s.

The rating is calculated by estimating the average fuel costs, divided by the floor area, and then adjusted to fit on the scale of 1–100+. The fuel costs are not the actual costs to the dwelling; they are taken from the Government Building Research Establishment Energy Model (BREDEM) calculation. It's shown on the SAP Worksheet. This is not actual predicted energy use (kWh/yr) although it can be reasonably accurate, however it only includes regulated energy, not unregulated energy such as cooking, small electrics etc. It's not possible to directly compare this energy use with other energy modelling, for example Passivhaus Planning Package (PHPP), mainly because the measurement conventions are different. For example, PHPP measures externally and SAP measures internally.

Example SAP Worksheet Showing SAP Rating



11a. SAP rating - individual heating systems including micro-CHP

Energy cost deflator (Table 12)	0.42	(256)
Energy cost factor (ECF)	1.08	(257)
SAP value	84.95	
SAP rating (section 13)	85	(258)
SAP band	B	

12a. CO_2 emissions - individual heating systems including micro-CHP

	Energy kWh/year		Emission factor kg CO_2/kWh		Emissions kg CO_2/year	
Space heating - main system 1	5292.09	x	0.216	=	1143.09	(261)
Space heating - secondary	845.83	x	0.019	=	16.07	(263)
Water heating	2288.91	x	0.216	=	494.40	(264)
Space and water heating			(261) + (262) + (263) + (264) =		1653.57	(265)
Pumps and fans	75.00	x	0.519	=	38.93	(267)
Electricity for lighting	501.80	x	0.519	=	260.43	(268)
Total CO_2, kg/year			(265)...(271) =		1952.92	(272)
Dwelling CO_2 emission rate			(272) ÷ (4) =		13.20	(273)
EI value					86.44	
EI rating (section 14)					86	(274)
EI band					B	

EPC Rating and Environmental Impact Rating (EI)

The EPC rating is the SAP rating above but divided up into bands A–G. An average UK dwelling would be an E; an average new build, B–C; a zero-carbon home an A; and a tent, G.

The EI is based on the estimated CO_2 emissions per m^2 from space heating/cooling, water heating, ventilation and internal lighting, minus CO_2 emissions saved by electricity generation. It's expressed in the same way as the EPC rating 0–100 and A–G.

Example EPC Showing EPC Ratings

Energy Performance Certificate

Dwelling type:	Semi-detached house	**Reference number:**	
Date of assessment:	10 April 2017	**Type of assessment:**	SAP, new dwelling
Date of certificate:	10 April 2017	**Total floor area:**	229 m²

Use this document to:

- Compare current ratings of properties to see which properties are more energy efficient
- Find out how you can save energy and money by installing improvement measures

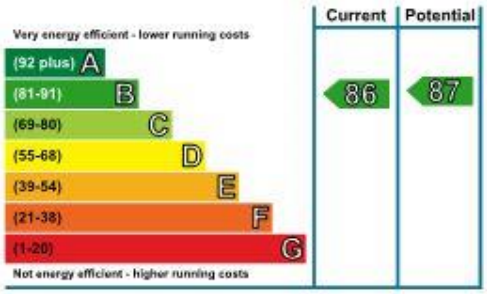
Estimated energy costs of dwelling for 3 years:	**£ 3,375**
Over 3 years you could save	**£ 249**

Estimated energy costs of this home

	Current costs	Potential costs	Potential future savings
Lighting	£ 312 over 3 years	£ 312 over 3 years	You could save £ 249 over 3 years
Heating	£ 2,406 over 3 years	£ 2,409 over 3 years	
Hot Water	£ 657 over 3 years	£ 405 over 3 years	
Totals	**£ 3,375**	**£ 3,126**	

These figures show how much the average household would spend in this property for heating, lighting and hot water and is not based on energy used by individual households. This excludes energy use for running appliances like TVs, computers and cookers, and electricity generated by microgeneration.

Energy Efficiency Rating



The graph shows the current energy efficiency of your home.

The higher the rating the lower your fuel bills are likely to be.

The potential rating shows the effect of undertaking the recommendations on page 3.

The average energy efficiency rating for a dwelling in England and Wales is band D (rating 60).

The EPC rating shown here is based on standard assumptions about occupancy and energy use and may not reflect how energy is consumed by individual occupants.

Actions you can take to save money and make your home more efficient

Recommended measures	Indicative cost	Typical savings over 3 years
1 Solar water heating	£4,000 - £6,000	£ 252

Page 1 of 4

Model Dwelling

Table 1: Model Dwelling England (TER/TFEE) Values Compared to Part L Regulations

Element	**Value Model Building (TER/TFEE)**	**Building Regulations 2013 England**
Opening area	Same as the proposed dwelling to 25% of floor area	N/A
External walls	0.18 W/(m^2K)	0.3 W/(m^2K)
Party walls	0 W/(m^2K)	0.2 W/(m^2K)
Floor	0.13 W/(m^2K)	0.25 W/(m^2K)
Roof	0.13 W/(m^2K)	0.2 W/(m^2K)
All windows	1.4 W/(m^2K)	2 W/(m^2K)
Opaque doors	1 W/(m^2K)	2 W/(m^2K)
Semi-glazed doors	1.2 W/(m^2K)	2 W/(m^2K)
Air tightness	5 m^3/(h.m^2)	10 W/(m^2K)
Linear thermal transmittance	SAP psi values or 0.05 W/(m^2K) if actual is 0.15 W/(m^2K)	0.15 W/(m^2K)
Ventilation	Natural with extract fans (2 fans up to 70m^2 TFA; 3 fans 70–100m^2 TFA; 4 fans over 100m^2 TFA)	N/A
Air conditioning	None	
Heating: gas boiler with fan flue to radiators	89.5% efficiency	88% efficiency
Heating controls	Time and temperature zone control, weather comp, modulating boiler with interlock	Programmer, room stat and TRVs, interlock
DHW system	Heated by boiler; if cylinder specified 150 ltrs in heated space, cylinder stat and separate time control	Cylinder stat and separate time control
Primary pipe work	Fully insulated	Fully insulated
Hot water cylinder loss factor if specified	Equal or better than 0.21 kWh/day	0.32 kWh/day
Secondary heating	None	N/A
Lighting	100% low energy	75% low energy
Thermal Mass Parameter (TMP)	Medium = 250 (masonry construction)	N/A

As can be seen from Table 1, above, the values for the building fabric in the Model Dwelling are considerably lower than the maximum allowed to achieve values in the Part L Approved Document, and therefore these Model Dwelling figures should be used as the basis for forming any targets to achieve in a design. It should be noted, however, that the SAP calculation works by taking all the above inputs into account, therefore if one performance value is better than the above, another can be less, and *vice versa*. A design strategy in terms of energy efficiency needs to encompass ALL input into the SAP calculation as it's the overall DER and DFEE figures, derived from the input, that will determine if the dwelling passes or fails.

Table 1, above, is taken from Approved Document L1A 2013 England Section 5 Model Designs and, if it is followed, the dwelling would normally pass.

Similar information is available in Appendix B Approved Document L1A Wales.

There you have it. If you follow the Model Design as indicated in the Approved Document, your dwelling will pass. Unfortunately, it often does not.

Throughout this book, I will be referring to test dwellings. These are eight different but typical dwelling types that I have used to test and compare the SAP results.
They are:

- Ground floor, mid floor/top floor flats
- Mid and end terrace house
- Semi detached house (effectively the same as an end terrace)
- Standard detached house (same floor area on the ground and first floor)
- Non-standard detached house (differing floor areas, dormers etc)

The results from entering the Model Building into the SAP for these real examples demonstrates that not all will pass Criterion C1, the DER/TER, using the standard Model Dwelling specification (see Table 2, below). Fortunately, they do all pass the Fabric Energy Efficiency Criteria.

In my experience, the DER fail is usually because of two issues:
First, if there is no secondary heating specified in the proposed dwellings. The Model Design also does not have secondary heating, but as soon as secondary heating (one that is additional to the main source of heating and usually in the living room of the dwelling) is specified, it will often pass, although this would often be a closed wood burner rather than a gas fire. If secondary heating cannot be specified, then something else within the calculations must be improved so that it is better than the Model Dwelling Value.

Second, The Dwelling Fabric Energy Efficiency Value can largely be down to how the Thermal Bridging psi values are defined. Here, Approved Construction Details (ACDs) or better alternatives usually need to be specified unless considerably better U-Values than the Model Dwelling are specified throughout the remainder of the calculation. For more details see Part Two, Section 7.

The main reason I believe the above Test Dwellings and other real assessments do not pass Criterion 1 is because there is no secondary heating specified, or it's the psi values applied in the Thermal Bridging calculation in the proposed dwellings.
More on this in Part Two, Section 8.

Table 2: Test Dwellings: SAP Results Using the Model Dwelling Values From Table 1

Dwelling Type	Built Form	DER	TER	Var %	DFEE	TFEE	Var %
House	Detached	16.18	15.73	102.87	51.59	55.58	92.82
House	Semi detached	15.10	14.29	105.66	47.79	49.42	96.70
House	End terrace	19.32	18.76	103.00	49.80	51.20	97.26
House	Detached	19.37	18.46	104.96	60.62	62.85	96.44
House	Mid terrace	18.04	17.60	102.52	44.02	45.16	97.48
Flat	Top Floor	16.40	16.66	98.42	40.42	45.09	89.64
Flat	Ground floor	16.07	16.31	98.53	39.93	44.59	89.53
Flat	Mid floor	14.98	14.67	102.07	35.93	37.29	96.35

SAP Conventions

SAP Conventions or SAP Default Values apply to SAP 2012 throughout the UK. Conventions applied for design-stage calculations submitted to Building Control are usually carried through to the As-Built stage unless there has been an update between the two, in which case the latest Conventions apply. SAP provides Default Values for many of the input fields, e.g. window U-Values and boiler efficiency.

Whenever specific product information is available, that should be used rather than Default Values, and of course will usually give a better result.

However, when using any specific values there needs to be documentary evidence to support them, and such evidence should be made available to Building Control upon request.

For items using the Product Database, the evidence required is that the specific named product, e.g. boiler, is the one being used. At the end of each Section in Part Two the specific requirements of the SAP Conventions relevant to that Section are listed.

In a Nutshell: A Summary of SAP Input, the requirements for a SAP assessment and EPC Conventions, and what achieves the best results.

The full effect of how the various input in SAP affects the final result and whether the dwelling will pass the Building Regulations is covered in depth in Part Two. This next section summarises all of Part Two. Therefore, if you want to gain an overview of what really makes a difference in SAP, this section will cover that.

All input is referenced to the effect each has on the DER and DFEE figures, as these are the two main criteria for a pass in SAP. Both must be equal to or lower than the target figures, TER and TFEE.

Section 1: Drawings

The only way to get an accurate assessment completed is from a good set of design drawings and a specification. The minimum drawings required are as follows:

- Site Plan
- Floor Plans
- Elevation Drawings
- Sections Drawings through all orientations

I have been asked to carry out calculations where at least one of the above may be missing, especially Sections (I won't, by the way), but to provide a calculation of any worth all of the above must be provided.

Section 2: Job Details

Dwelling: Key Inputs

For any assessment to commence, a full address and postcode are required.

Thermal Mass Parameter (TMP)

If a dwelling has a low TMP it will have a lower DER/DFEE than one with a medium or high TMP. A low TMP would typically be a timber frame construction. A lightweight block in a cavity construction may also be a low TMP. This is because the TMP is measured for the first 100mm of the construction from the inside of the dwelling; everything past the first 100mm is ignored.

Sheltered Sides

Generally, the more exposed the dwelling, the higher the DER/DFEE will be.

Orientation

The orientation usually refers to the direction that the front entrance door faces, but this in itself is of little consequence to the results. However, this is also linked to the openings and, by changing the orientation, it affects the dwelling's openings, so the effect on the DER/DFEE will be dependent very much on the number and orientation of the openings.

Dwelling Storeys and Overall Volume

The SAP Calculation will use the volume of the dwelling, and this is dependent on the number of storeys, their average height, and the area of each. The higher the volume of the dwelling, the higher the DER/DFEE.

If the Storey Height remains constant, but the floor area increases, the DER/DFEE are lower.

This Section in Summary: a dwelling with a low thermal mass, i.e. lightweight, a larger floor area to storey-height ratio, i.e. compact, with sheltering from all sides, and consideration with regards to opening orientation, ideally the largest being South facing, would together give the lowest DER/DFEE.

Section 3: Heat Loss Floors

Floors: Key Inputs

Heat loss floor Area and Zone 1 Area (Living Room)

The greater the m^2 of heat loss floors, the higher the DER and DFEE. Likewise, the larger the proportion the Zone 1 area is, the more this will affect the DER.

U-Value

Linked to the heat loss floor area is their U-Value. The higher the U-Value and the larger the m^2 heat loss area, the worse (higher) the DER and DFEE.

Heat loss floor U-Values are themselves varied by the Floor area m^2 and the heat loss perimeter. The notional Model Dwelling will use a U-Value of 0.13.

A copy of all heat loss floor U-Values must be available for final As-Built calculation and EPC.

All heat loss floors must be included in the calculation; heat loss floors other than ground floors are those above unheated spaces, garages, corridors etc, and overhangs.

This Section in Summary: the smaller the floor area, heat loss perimeter and the lower the U-Value, the lower the DER/DFEE. The smaller the Zone 1 area, the lower the DER. All heat loss floors are included in the calculation, not just the ground floor.

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