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A Study into the Variability of UK Domestic Energy Assessments

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ABSTRACT

In the UK, the residential sector accounts for around 29% of overall energy consumption. After transport, it is the largest single consumer of energy, and is responsible for approximately 14.5% of greenhouse gas emissions. There is a growing need to address this, if ambitious and binding targets are to be met by 2050. A fundamental part of this broad context is the ability to be able to measure the energy efficiency of a residential building accurately and consistently, so that progress against targets can be measured, current emissions can be calculated, and robust data can be used to formulate policy. The focus of this research is primarily that of assessing a property's energy efficient status by the Domestic Energy Assessor (DEA), to ascertain whether there is variability in the results of the energy performance certificates (EPCs) they produce using the RdSAP software model, that will have implications for the wider context outlined here. In achieving this, the research utilises a mixed methods approach to look first at the findings of a number of semi-structured interviews with practising DEAs, and following this, it analyses site-based energy performance certificates (EPCs) undertaken by DEAs at two control properties. The information produced during both exercises is scrutinised, and synthesised with existing literature, and targets practitioners, academics and those involved in the creation of energy efficienct policy for residential buildings. The results present a contribution to knowledge by identifying variability within EPC outputs, which is widely acknowledged by practising DEAs, further supported during the site based study of two buildings, and underpinned by the literature. This variability may be attributed to different stages of the energy surveying process, and a variety of reasons, including the way the EPC is perceived (by both the DEAs producing them and the public), the training and experience of DEAs, how EPCs are audited, and conflicts of interest surrounding the commissioning of EPCs. The research concludes by summarising the findings and making proposals, which will help to support the development of a more effective process in assessing the energy efficient status of residential buildings.

Keywords: DEA, EPC, Energy Efficiency, Assessment, Residential, Buildings, RdSAP

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GLOSSARY

DEA	Domestic Energy Assessor
EPC	Energy Performance Certificate
ECO	Energy Company Obligation
NCM	National Calculation Methodology
NHBC	National House Building Council
EPBD	Energy Performance of Building Directive
SAP	Standard Assessment Procedure
RdSAP	Reduced Data Standard Assessment Procedure
CERT	Community Emissions Reduction Target
CESP	Community Energy Saving Programme
Ofgem	Office of Gas and Electricity Markets
DECC	Department of Energy & Climate Change
BRE	Building Research Establishment
HHCRO	Home Heating Cost Reduction Obligation
BREDEM	Building Research Establishment Domestic Energy Model
EI	Environmental Impact (score)
GHG	Greenhouse Gas (emissions)
NHER	National Home Energy Rating
DCLG	Department of Communities and Local Government
NOS	National Occupational Standards
CPD	Continuing Professional Development
EST	Energy Saving Trust
RICS	Royal Institution of Chartered Surveyors
EHS	English Housing Survey
MHCLG	Ministry of Housing, Communities & Local Government
RHI	Renewable Heat Incentive
FIT	Feed In Tariff
TMO	Technical Monitoring Officer
LCS	Lifetime Carbon Savings
GPS	Global Positioning System
BEIS	Department for Business, Energy & Industrial Strategy
GHG	Greehouse Gas (emissions)

CHAPTER 1: INTRODUCTION

1.0 BACKGROUND AND JUSTIFICATION

This research explores the phenomenon of variability within energy performance certificates (EPCs), which are provided for residential buildings in the UK. This is important because EPCs are used more widely and for more varied purposes than ever before. These uses have expanded from the EPC's originally designed function (just over a decade ago) as a tool to appraise the energy efficient status of a single dwelling, to that of a carbon (emissions) calculator, a tool for the assessment of suitability for grant funding for energy efficient improvements, a tool used to assesss the suitability of a property for residential letting purposes, and arguably most importantly, the scrutiny of EPC data en masse to appraise the energy efficient status of a group, region or even a nation's housing stock. As EPCs continue to become more widely used for this broadening range of purposes, the ramifications for variation are, correspondingly, more important than ever. There is limited research on this subject, and this thesis identifies and fills a gap in the existing knowledge.

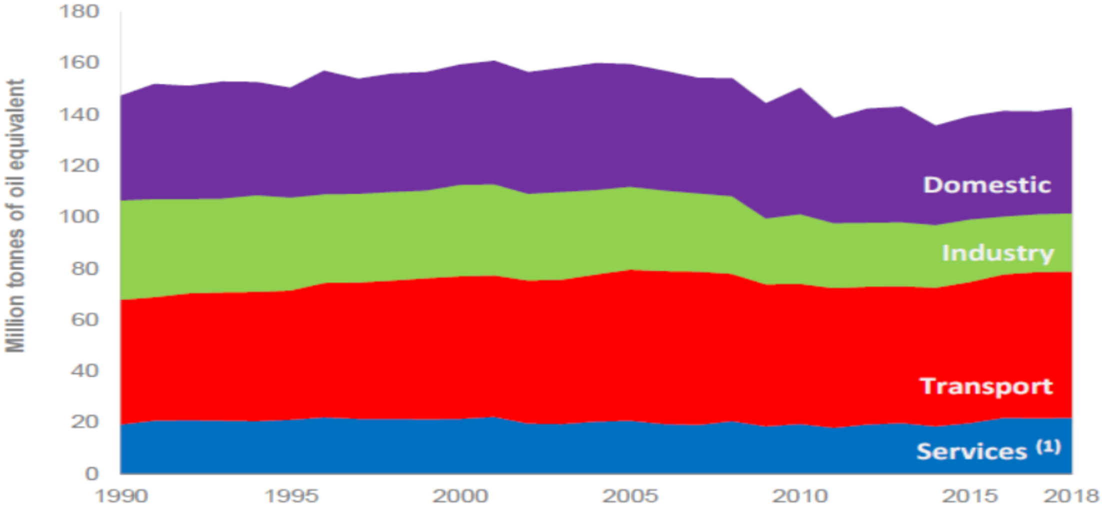
This introduction outlines the researcher's position and sets out the research aims and objectives. Following this, a literature review will analyse existing material on the energy performance of buildings and their certification for the purpose of benchmarking. After the literature review, a mixed methods research design is first justified, then adopted, with two distinct strands. The first, qualitative strand takes the opportunity to interview practicing energy assessors in order to gauge their opinion on variability. The second, quantitative strand is divided into two phases, where energy performance certificates are produced by twenty energy assessors, on two properties with varying attributes. The two strands of research, and the material contained within the literature review are then synthesised, and conclusions are drawn.

A fundamental part of meeting the ambitious and binding targets of the 2008 Climate Change Act is a need to measure the energy efficiency of a building accurately and consistently. With the capacity to do this, benchmarks can be set and progress against targets can be measured, robust data can be published so that stakeholders can review current status, and policy may be formulated. This study is underpinned by the process through which the energy assessor must go to establish the energy efficient status of a domestic dwelling by using the EPC model, in order to identify where there is scope for erroneous data to find its way into the EPC, and how the process may utlimately affect EPC accuracy. Prior to the study having commenced, the researcher had formed a hypothesis that energy performance certificates may not be wholly consistent or reliable, due to anecdotal feedback received pointing to this issue. This will be elaborated upon as the thesis unfolds.

Establishing the energy efficient status of a building has become an increasingly important function as the increased pressures of the Climate Change Act, and the increasing costs of fuel are brought to bear. This is the context within which - as noted above - the energy performance certificate (EPC) is used more widely, and there is increased reliance by policy makers and consumers on its outcomes. Because of this, there is now greater pressure than ever to ensure reliability and consistency of dwelling energy performance data.

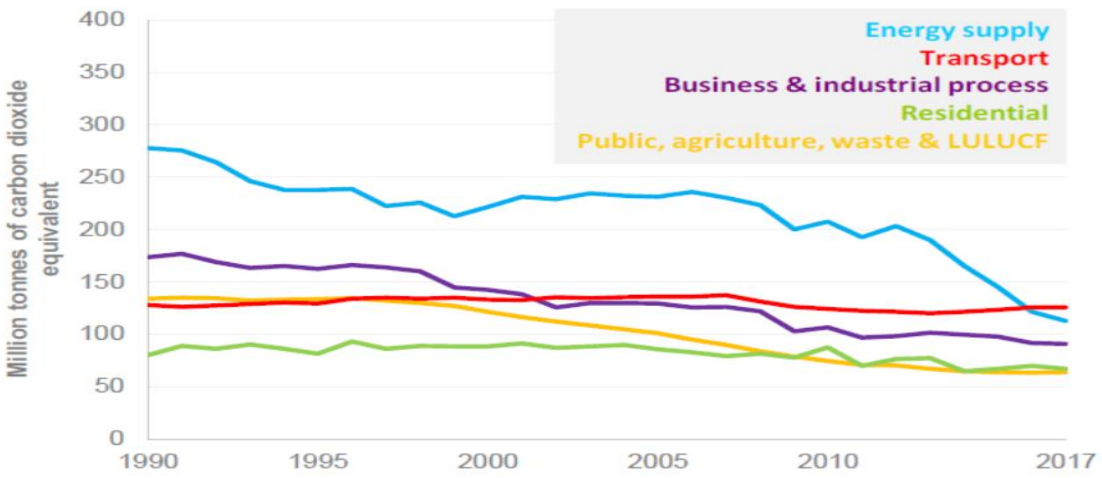
1.0.1 Context and bounding

Energy use within buildings can be categorised into two quite different and distinct areas. Firstly, there is *embodied* energy use: the energy associated with the construction of the building, including its materials. Secondly, there is the *operational* energy use, which is the energy associated with the use of the occupied building once it is constructed, throughout its lifetime (RICS, 2017). Trying to apportion the proportion of carbon emissions of a building to each of these distinct categories can be challenging, primarily because the key variables of the building lifecycle, and the materials from which it is constructed can vary considerably and will have a notable impact on embodied versus operational energy use (Hacker et al., 2007). The NHBC (National House Building Council) Foundation undertook a study of its own in (Iddon and Firth, 2011) which modelled various building lifecycles and materials, and concluded that embodied carbon accounted for between 25% and 40% of new buildings, after also finding that reducing operational carbon led to an increase in the proportion of embodied carbon emissions. While embodied carbon emissions in residential construction may form an interesting study remit of its own, the EPC concerns itself with the operational energy of a building. In the UK, the residential sector accounts for around 29% of operational energy consumption, and residential buildings emitted approximately 14.5% of total UK greenhouse gas emissions in 2018 (BEIS, 2019). Figures 1 and 2 below show that the residential sector is the second largest consumer of energy in the UK (Fig 1), and a major contributor to greenhouse gas (GHG) emissions. It is clear to see why there is considerable attention given to reducing building-related carbon emissions therefore, in order to achieve the target set out in the 2008 Climate Change Act.



2018					Million tonnes of oil equivalent
	Industry	Domestic	Transport	Services[1]	Total
Coal & manufactured fuels	1.3	0.5	0.0	0.0	1.9
Gas	9.1	26.6	-	8.1	43.8
Oil	2.2	2.5	55.2	3.7	63.6
Electricity	8.0	9.0	0.4	8.3	25.8
Bioenergy and heat	2.1	2.6	1.4	1.6	7.7
Total	**22.7**	**41.2**	**57.0**	**21.8**	**142.7**

Figure 1, showing total energy consumption from 1990 to 2018, broken down by sector. Source: UK Energy in Brief, BEIS, 2019



	Million tonnes of carbon dioxide equivalent					
	1990	2000	2005	2010	2016	2017
Energy supply	277.9	221.6	231.5	207.4	121.8	112.6
Residential	80.1	88.7	85.7	87.5	69.8	66.9
Public, Agriculture, Waste Management and LULUCF	134.4	121.4	101.0	74.7	63.6	63.8
Business and Industrial process	173.9	142.5	129.5	106.7	91.9	91.0
Transport	128.1	133.3	136.0	124.5	125.9	125.9
Total greenhouse gas emissions	**794.4**	**707.5**	**683.7**	**600.9**	**473.1**	**460.2**

Figure 2, showing greenhouse gas emissions by sector, from 1990 to 2017. Source: Ricardo Energy & Environment, BEIS, 2017

In new buildings, the Building Regulations (Part L1A of the UK Building Regulations) is the regulatory framework through which operational energy demand is addressed, and a legislative drive towards net zero operational carbon emissions, while postponed from an anticipated 2016 implementation date, is nevertheless underway (BEIS, 2019). This is very much a current theme, with the government's Energy White Paper (BEIS, 2020) marking the introduction of the 'Future Homes Scheme' for new building, which aims to introduce new residential buildings with 75% to 80% lower carbon emissions than existing new buildings. There is much discussion about EPCs in the Energy White Paper as the driver to mark progress. However, in the interests of bounding the focus of this thesis, both embodied carbon, and carbon emissions associated with the operational requirements of new buildings are not investigated further here. Increasing the energy efficiency of the nation's *existing* building stock, referred to as the 'retrofit agenda' by Kelly (Kelly et al., 2009) and forms the scope for this thesis.

In narrowing the thesis remit further to a focus on the energy efficiency of the nation's existing housing stock, if one may be allowed to set aside weather conditions for the time being (as they are beyond our control), then this too can be divided into two distinct, albeit intertwined areas. Energy use within an existing building may be said to be determined by its technical and architectural characteristics on the one hand, and by the behaviour of its occupants on the other (Papakostas, 1997). The parameters that influence energy demand for space heating within a dwelling, beyond the obvious need to accommodate the region's weather conditions, are the thermal attributes of the building and its archetype (i.e., construction methods used, and whether the building is a flat, bungalow, house, followed by flat type, house type etc.) and the occupant's behaviour, or use of the dwelling. Occupant behaviour is thought to have a notable influence on the variation of energy consumption in households. Studies of energy use by occupants have identified variations in energy use that are not easily explained by basic characterstics such as household size, level of education and age distribution (Santin et al., 2009). However, in categorising and comparing the number of individuals within a household, household income, average age and even education/socio-economic background, Santin did not only create her own study, but looked at, and compared her results with other studies that pointed to correlations between these characteristics and energy use. In her discussion about occupant behaviour, Santin concluded that while some authors attributed far greater variability of energy efficiency use to occupant behaviour, her own study pointed to the overall effect as having much less of an impact on total energy use than the physical dwelling attributes themselves. Another interesting concept in considering occupant behaviour is that of a 'rebound effect', also known as the Jevons Paradox (Polimeni et al., 2009). This may be summarised as the saving of less energy than anticipated, or calculated, after installing energy efficiency improvements due to a proportion of the improvement's benefit being used for added comfort. Gillingham (Gillingham, Rapson and Wagner, 2015) writes a paper devoted entirely to this phenomenon, and takes the concept a step further with discussion about 'backfire', a sort of 'rebound-plus', where more energy is actually used after improvements are undertaken, although he asserts there is actually limited evidence for this. However, occupant behaviour could be described as a self-contained topic. As with the notes made in respect to embodied and operational energy earlier in this introduction, in the interest of bounding the discussion still further, occupant behaviour will not be discussed in any detail here. It may be important now after having noted in some detail a number of associated areas that will not be the focus of this research, to elaborate on what the focus *will* be, and why this important.

1.0.2 The study focus and the Energy Performance Certificate (EPC)

The UK's existing residential building stock is much older than that of many other developed countries in the world. Approximately 40 per cent of UK buildings were constructed prior to 1944 (MHCLG, 2017; Dixon et al., 2008; Fylan et al., 2016), and in respect to the energy efficiency of buildings, this presents additional challenges for the UK over its European counterparts. Furthermore, it is estimated that over three quarters of buildings in use today will still be standing in 2050 (Fylan et al., 2016). The English Housing Survey (MHCLG, 2017) data records a total of 23.1% of all English housing stock as having solid walls, almost all of which were constructed over a hundred years ago. This type of wall presents a greater technical challenge in terms of retrospective insulation and increasing energy efficiency, being categorised as hard-to-treat (Dowson et al., 2012), which will be looked at in some more detail later in this research. Also presenting more complex challenges for insulation are older, 'non-traditionally constructed' (BRE, 2012) properties with steel, concrete and timber frames. While some more recently constructed timber framed properties may be relatively energy efficient, this constitutes a small minority of the total of these property types, which constitute a further 12.3% of all English stock.

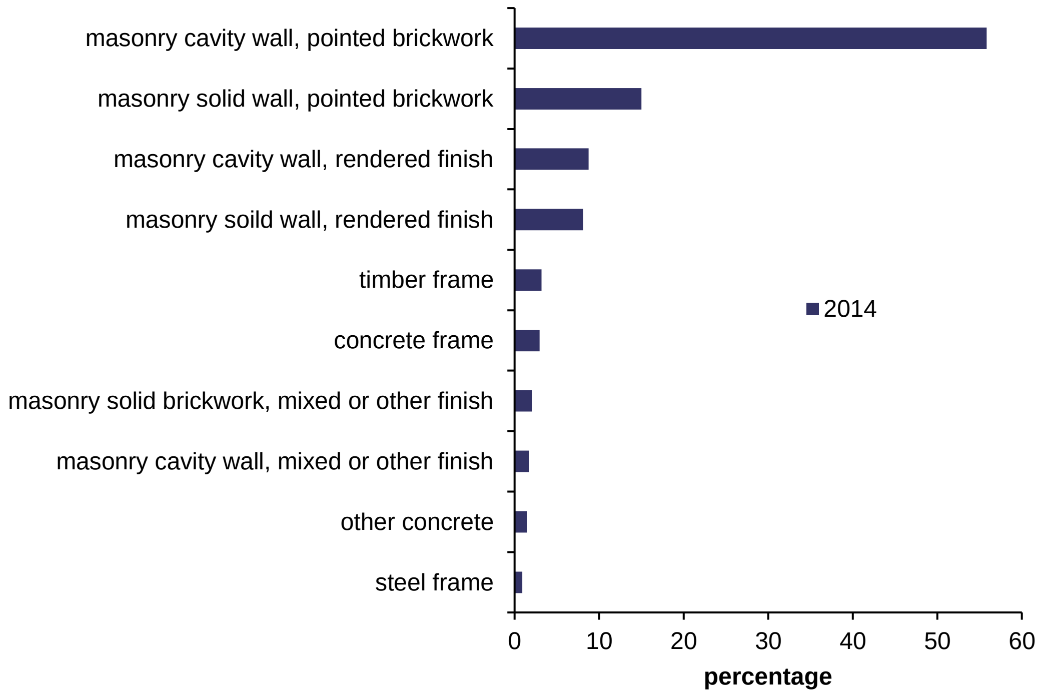


Figure 3. Construction type of English housing stock, recorded for the 2014 English Housing Survey. Source: MHCLG, 2018

In consideration of this, it may be reasonable to assert that the age of UK housing stock, coupled with the added complexities that are inherent in improving the energy efficiency of older and non-traditionally constructed properties, as well as those with narrow or 'hard to treat' cavity walls (Dowson et al., 2012), all adds to the challenge of improving the nation's existing housing stock, and the EPC has become central to the monitoring of this challenge.

As noted, the EPC as a tool for accurately modelling the energy efficient status of a building is central to this study focus, and this function has very important social implications too. For example, in 2014, the government introduced a new statutory fuel poverty target for England (DECC, 2014). The aim is to ensure that, where practical, as many fuel poor homes as possible will be rated EPC band C by 2030, with interim milestones along the way. Figure 4 and Table 1 below show the UK government's progress toward this target, as of 2017 (BEIS, 2019). Clearly, if the EPC is not accurate, then the data presented here would not be reliable. This has implications both for benchmarking status, such as that shown in the figure and table below, but also for the formulation of future policy, which this data may well feed in to.

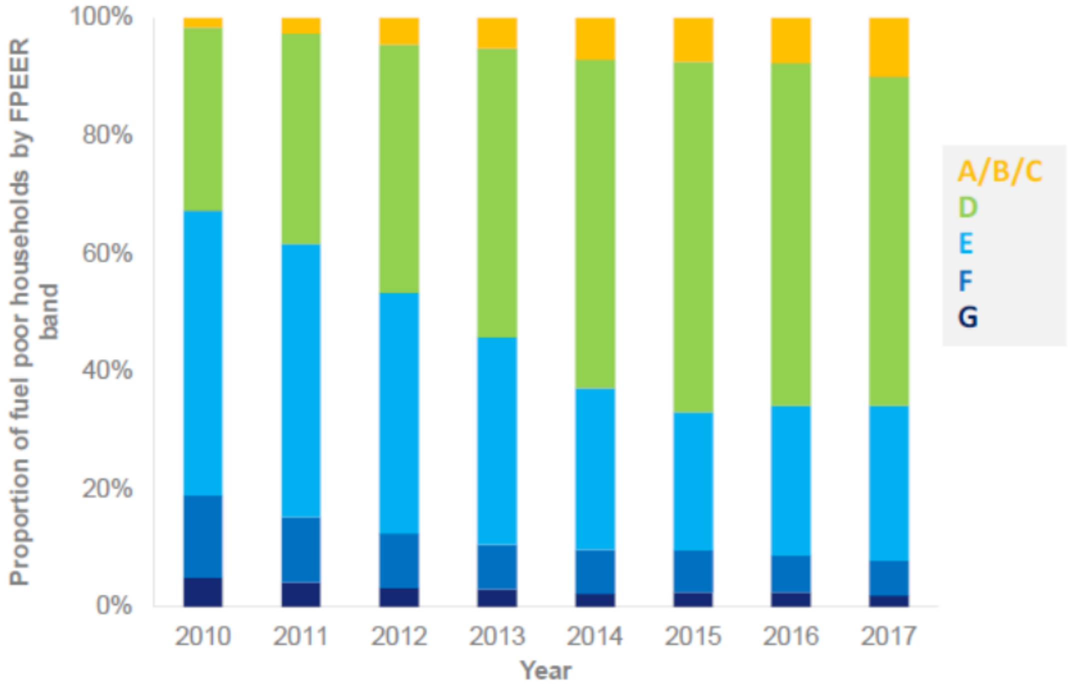


Figure 4 above and Table 1 below, showing the fuel poor population by EPC band. Source: UK Energy in Brief, BEIS, 2019

Target year	Fuel poverty target	2010 (%)	2017 (%)	Percentage point change
2020	Band E or above	81.1	92.2	11.1
2025	Band D or above	32.7	65.9	33.2
2030	Band C or above	1.5	10.0	8.5

It is because new housing stock is being added at a rate only of around 1% per year (Fylan et al., 2016), and such a large proportion of existing housing stock will remain in situ and inhabited for many decades to come, that measurement of the energy efficient status of our existing housing stock is important. This introduction has thus far have served to outline that a housing stock's status, be it that of an individual building, a social landlord's portfolio, or that of the entire nation cannot be benchmarked effectively for a range of objectives - many of which one may argue are more important now than ever - if its energy efficient status cannot be measured accurately and reliably.

In addressing this conundrum, the research will unfold by first reviewing the relevant existing literature, after which a methodological approach is explored and selected, and two strands of case study research are followed. The first strand involves conducting semi-structured interviews with accredited energy assessors to glean their thoughts about the energy assessment process and the resulting EPC. As part of a second strand of research, energy assessors are invited to undertake an EPC at two control properties, with the results of their EPCs compared and contrasted with one another for the purpose of identifying variability. The results of these two strands of research are analysed and synthesised with existing knowledge in an attempt to address the aim and objectives of the research, which are laid out in Section 1.2 below.

1.1 RESEARCHER POSITION

Having begun to refine this research focus in the introduction, before moving to Chapter 2 where an analysis of the existing literature sits, the author's position may be recorded for the purpose of transparency. This research is written by a practitioner immersed in the operational world of energy assessments for residential buildings, primarily for existing housing stock. During time spent working in this environment, anecdotal evidence has been collected that would indicate there may be a degree of variability to assessments, and that outputs are not necessarily as reliable as might be expected (Gledhill et al., 2016). With an increasing use of energy assessments for wider and more varied purposes, such as that within the English Housing Survey, for MEES - Minimum Energy Efficiency Standards for rented properties, and for retrofit energy efficient improvements, including the Renewable Heat Incentive, Feed in Tariff, the largely defunct Green Deal and, until recently, the Energy Company Obligation, all of which will be discussed later in this research (and all of which the researcher has had some professional involvement with) the need for reliable outputs from energy assessments may be considered greater now than ever. The consequences for inaccuracies may have financial and policy related consequences of some scale. However, there is a lack of academic and practitioner-led research on the subject, and this research looks to address this, by laying out the following aim and objectives:

1.2 AIM AND OBJECTIVES

The aim of this research is *'to understand the importance of the energy performance certificate (EPC) in the UK, identify the risks that may affect its accuracy, appraise the EPC process in detail, and develop potential recommendations for the future delivery and use of EPCs'*

In achieving this aim, the objectives are to:

1. Understand the current context of the EPC, and its uses by different stakeholder groups.

2. Identify the risks to the accuracy of EPCs by understanding the assessor perspective.

3. Explore the process of EPC delivery through a designed research approach looking specifically at variation determined by practice between asessors during the assessment process.

4. Identify possible improvements in the energy assessment process, as well as effective uses for the EPC and future avenues of research.

1.3 ORIGINAL CONTRIBUTION TO KNOWLEDGE

The completed research will contribute to knowledge by providing a rigorous study into establishing the variability or otherwise of energy performance certificates. This contribution to knowledge is important because a) there is limited research and literature regarding domestic energy performance certificate variability at present, and b) there is an increasing reliance on energy performance certificates which in turn increases the need for robust reporting of data.

1.4 CHAPTER BREAKDOWN

Having introduced the research topic in this section, and outlined the researcher's position, as well as the aim and objectives, this section is completed by presenting a breakdown of the chapters which follow:

Table 2: breakdown of the chapters which follow

Thesis **A study into the Variability of UK Domestic Energy Assessments**	
Chapter 1	**Introduction** Pp 1 – 12
Chapter 2	**Literature Review** *Summarised as:* Overview of the EPC The EPC model: SAP and RdSAP Criticims of the EPC model The policy context of the EPC Modelling EPC data en-masse The perception of the EPC Domestic Energy Assessors, Accrediting Bodies, and auditing DEA variability and EPCs Summary Pp 14 - 87

Chapter 3	**Study Methodology** *Summarised as:* Introduction Defining research Research paradigms Philosophical assumptions Developing a theory Research philosophies Research strategies Mixed Methods research Justification for Mixed Methods approach Mixed Methods research design The Exploratory Sequential research design Research methods Data analysis Data validation Research timeline Limitations Ethics Summary Pp 89 – 132
Chapter 4	**Qualitative Study** *Summarised as:* Domestic Energy Assessor (DEA) interviews Introduction Results Discussion Pp 134 – 155
Chapter 5	**Quantitative Study** *Summarised as:* Introduction Research model and respondent identification Practical considerations and limitations Site Based EPC 1 Site Based EPC 2 Summary Pp 157 – 232
Chapter 6	**Discussion** Introduction EPC quality and perception EPC auditing Conflicts of interest RdSAP automated bias The EPC process and TQM DEA training and experience Summary Pp 234 – 248

Chapter 7	**Conclusions** Introduction Main findings and recommendations Key contributions of the research Limitations Opportunities for further research Summary and final statement Pp 250 – 266
References	

CHAPTER 2: LITERATURE REVIEW

2.1 INTRODUCTION

This literature review will cover a broad range of aspects relating to energy efficiency in buildings: all those that may bear relevance to the study focus. This range of aspects will however be bound by, and linked back to, the study focus – the variation of Energy Performance Certificates, and how this variation may come about. The narrative of the literature review may flow best by starting broad; giving context and background, and narrowing the focus as the chapter unfolds. As the aim of the research is to identify the existence or otherwise of EPC variability, the EPC process may be seen to sit at the core of the study, and so discussion about the EPC process is placed at the end of the literature review. This comes after the review has built up the context, explaining why EPC variability is important and what impacts it might have. The overall aim of the literature review is to provide context and background in addition to discussion of the core topic, which helps to lead into the following, methodological and case study related chapters with greatest possible ease for the reader.

In short, the literature review will unfold as follows:

- An explanation about what the EPC is, what it's for, and how it came to be, moving on to how it works, including;
    - The basic building physics principles of the model,
    - SAP and RdSAP (the model 'engine'), and
    - Some criticisms of the model from a building physics perspective.
- The different uses that the EPC is put to, including;
    - a discussion about the political context that surrounds energy efficiency in residential buildings, and where the EPC sits within this.
    - how and into what areas the EPC's uses are broadening, including the use of EPC data en-masse, and
    - identification and clarification of issues regarding why the EPC may, or may not be appropriate in these circumstances.
- The EPC *process*, including;

- how is it produced,
- who produces it,
- how is quality maintained, and
- how might variability come about?

This final, EPC process section may be regarded as the central focus of the research. It will look in some depth at the DEAs who produce EPCs, and in particular their training and monitoring, the Accrediting Bodies – those institutions which are charged with administrating and policing EPCs in the UK, and at variability and how and in what ways this phenomenon might manifest in the production of EPCs. The literature review will end with a summary discussion of the findings.

2.2 THE ENERGY PERFORMANCE CERTIFICATE

2.2.1 The background of an Energy Performance Certificate

In order to understand our need to measure energy efficiency in buildings accurately and consistently, and the significance of the energy performance certificate at the heart of this, it is important to see what triggered the need for an EPC. Within the European Union, policies have been implemented which have related performance targets that have cascaded through to individual member states. In order to fulfil the requirements of the EU Directive 2002/91/EC on the Energy Performance of Buildings Directive (European Parliament and Council, 2003), EPCs were introduced in various stages throughout the UK from 2007 to 2009, after being selected as the government's National Calculation Model or NCM. This was at the expense of other energy calculation models that were in existence at the time, such as the now largely defunct National Home Energy Rating system (NHER, 2016). The primary function of the EPC was initially (and may still be considered to be) to 'enhance the role of building energy efficiency for all buildings sold and let' (Kelly et al., 2012).

In the UK, where more than a quarter of total carbon emissions are from residential buildings, (Palmer and Cooper, 2013) there is an obvious need to tackle this sector if the 2008 Climate Change Act's binding target of reducing carbon emissions by 80 per cent in 2050 from a 1990 baseline is to be achieved. Within this context, the EPC may be seen as a valuable contributor toward the aims of relaying current status, setting targets and measuring progress against targets (Stone et al., 2014; Gonzalez-Caceres and Vic, 2019; Palmer and Cooper, 2013).

2.2.2 What is an EPC?

Since 2009, with only a very small number of exceptions, all domestic (and commercial) buildings in the UK available to buy or rent must have an Energy Performance Certificate (EPC) (DCLG, 2010). Their aim, as the Energy Saving Trust puts it, is to ‘identify ways to save money on energy bills and improve a home’s comfort’ (EST, 2019). In much the same way as the multi-coloured sticker on new appliances, EPCs tell you how energy efficient a building is and give it a rating from A (very efficient) to G (inefficient). The EST suggest that EPCs let the person who will use the building know how costly it will be to heat and light, and what its carbon dioxide emissions are likely to be. Later in this chapter, there is some discussion about to what extent this statement is actually true. The EPC will also show what the energy-efficiency rating could be if improvements were made, and it highlights cost-effective ways to achieve a better rating.

EPCs are valid for 10 years from when issued (The Energy Performance of Buildings Regulations, 2007). A property's EPC must be made available to potential buyers at the outset of marketing a property for sale or rent, and this was (and one may argue still is) the primary function of an EPC (DECC, 2011). At its most simplistic, an EPC allows the reader to compare the energy efficiency of different properties easily (EST, 2019). However, its uses are now broadening, and this is discussed later in this chapter.

An EPC will also highlight the energy efficiency improvements that may be made, how much they will cost and how much money could be saved as a result of each installed measure. Later in this chapter there is some discussion about the figures presented on the EPC for energy use and potential savings, which are for a ‘typical’ household in that property (BRE, 2012) – they are not tailored to the occupants, or their lifestyle.

In brief, the EPC contents are discussed below.

2.2.3 EPC Page 1

Estimated energy costs of dwelling for 3 years:	£ 3,357
Over 3 years you could save	£ 276

Estimated energy costs of this home

	Current costs	Potential costs	Potential future savings
Lighting	£ 447 over 3 years	£ 258 over 3 years	You could save £ 276 over 3 years
Heating	£ 2,571 over 3 years	£ 2,394 over 3 years	
Hot Water	£ 339 over 3 years	£ 429 over 3 years	
Totals	£ 3,357	£ 3,081	

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.

Figure 5, EPC estimated energy bills, current and potential. Source: W-Y-P Gledhill, 2015

The first page of the EPC starts with an estimate of the current and potential energy bills of the property. This can give an indication as to how much it will cost to run in terms of energy bills, and how much lower the running costs could be if energy efficient measures that are deemed by the software model to be appropriate for the property are installed.

These costs are estimated for heating, hot water and lighting. The EPC doesn't include additional estimates for energy costs from your home appliances (such as the cost of running a fridge, oven, TV etc.) because these appliances may be considered optional, at least when compared with heating and lighting.

In this case, the potential savings add up to nearly £300 over three years in this three-bedroom terrace house.

2.2.4 Energy efficiency rating

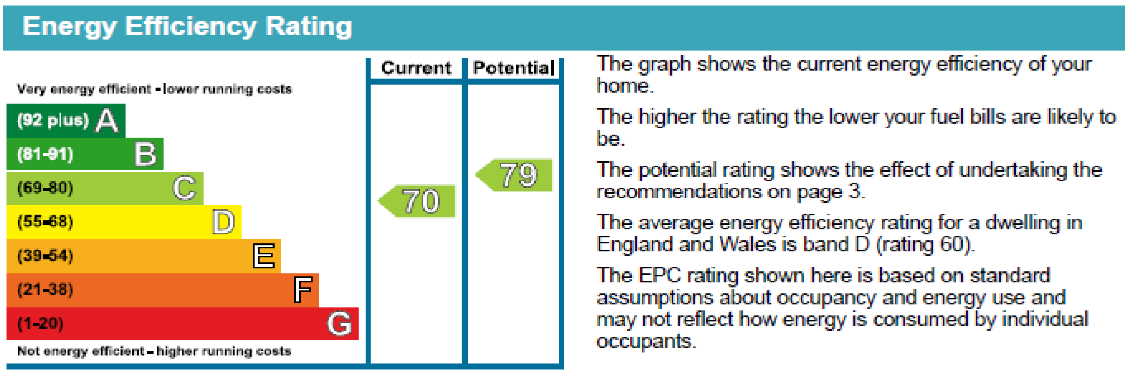


Figure 6, EPC SAP score A - G. Source: W-Y-P Gledhill, 2015

The next graphic on page one is a quick visual comparison of dwelling performance, which is similar in appearance to the energy labels you get on home appliances. The property is given a current energy efficiency rating. These range from A-G, with A being the highest. EPCs also have a similar chart for a property's environmental performance, on the last page of the document.

The EPC also shows the potential rating if all the suggested improvements are carried out. In this example, it can be seen that the dwelling could jump from a SAP score of C70 to C79 if all the recommended energy efficient improvements are carried out.

2.2.5 Top actions

Top actions you can take to save money and make your home more efficient		
Recommended measures	Indicative cost	Typical savings over 3 years
1 Low energy lighting for all fixed outlets	£80	£ 168
2 Replace heating unit with condensing unit	£2,200 - £3,000	£ 111
3 Solar photovoltaic panels, 2.5 kWp	£5,000 - £8,000	£ 876

Figure 7, EPC Top Actions. Source: W-Y-P Gledhill, 2015

This section is a summary of energy efficiency actions that may be taken, with the potential savings attached to each action. Only the highest priorities are given here, and further detail is presented on page three of the EPC.

2.2.6 EPC Page 2

Summary of this home's energy performance related features		
Element	Description	Energy Efficiency
Walls	Timber frame, as built, insulated (assumed)	★★★★☆
Roof	Pitched, 200 mm loft insulation	★★★★☆
Floor	Solid, limited insulation (assumed)	—
	To unheated space, limited insulation (assumed)	—
Windows	Fully double glazed	★★★☆☆
Main heating	Boiler and radiators, mains gas	★★★★☆
Main heating controls	Programmer, room thermostat and TRVs	★★★★☆
Secondary heating	None	—
Hot water	From main system	★★★★☆
Lighting	Low energy lighting in 27% of fixed outlets	★★★☆☆

Current primary energy use per square metre of floor area: 195 kWh/m² per year

The assessment does not take into consideration the physical condition of any element. 'Assumed' means that the insulation could not be inspected and an assumption has been made in the methodology based on age and type of construction.

Figure 8, EPC summary of features. Source: W-Y-P Gledhill, 2015

This page presents a breakdown of each element of the dwelling, with a description and an energy rating from one to five stars (five being the highest) to help the reader understand the effectiveness of its construction, heating and hot water system, and lighting. This may give the reader the opportunity to compare one property with the next, prior to making a decision to purchase, or rent. Later in this chapter, the impact this has on the decision-making process of prospective purchasers is discussed.

2.2.7 Low carbon energy

Low and zero carbon energy sources

Low and zero carbon energy sources are sources of energy that release either very little or no carbon dioxide into the atmosphere when they are used. Installing these sources may help reduce energy bills as well as cutting carbon. The following low or zero carbon energy sources are provided for this home:

- Solar water heating
- Solar photovoltaics

Figure 9, EPC low carbon energy sources. Source: W-Y-P Gledhill, 2015

In the middle of page 2, a list of any low or zero-carbon energy technologies is presented. The above screen shot shows a property with both solar water heating and solar PV for renewable electricity generation.

2.2.8 Heat demand

Your home's heat demand

For most homes, the vast majority of energy costs derive from heating the home. Where applicable, this table shows the energy that could be saved in this property by insulating the loft and walls, based on typical energy use (shown within brackets as it is a reduction in energy use).

Heat demand	Existing dwelling	Impact of loft insulation	Impact of cavity wall insulation	Impact of solid wall insulation
Space heating (kWh per year)	17,742	(658)	N/A	(7,506)
Water heating (kWh per year)	5,296			

You could receive Renewable Heat Incentive (RHI) payments and help reduce carbon emissions by replacing your existing heating system with one that generates renewable heat, subject to meeting minimum energy efficiency requirements. The estimated energy required for space and water heating will form the basis of the payments. For more information, search for the domestic RHI on the www.gov.uk website.

Figure 10, EPC estimated record of heat demand. Source: W-Y-P Gledhill, 2015

At the bottom of page 2 is a graphic presenting the anticipated energy demand of the property, and how the measures recommended earlier in the certificate may reduce this demand. This section is used to calculate Renewable Heat Incentive (RHI) payments (DECC, 2014), which will be discussed in more detail later in this chapter.

2.2.9 EPC Page 3

Recommendations

The measures below will improve the energy performance of your dwelling. The performance ratings after improvements listed below are cumulative; that is, they assume the improvements have been installed in the order that they appear in the table. Further information about the recommended measures and other simple actions you could take today to save money is available at www.gov.uk/energy-grants-calculator. Before installing measures, you should make sure you have secured the appropriate permissions, where necessary. Such permissions might include permission from your landlord (if you are a tenant) or approval under Building Regulations for certain types of work.

Measures with a green tick ✓ may be supported through the Green Deal finance. If you want to take up measures with an orange tick ✓ through Green Deal finance, be aware you may need to contribute some payment up-front.

Recommended measures	Indicative cost	Typical savings per year	Rating after improvement	Green Deal finance
Internal or external wall insulation	£4,000 - £14,000	£ 510	E51	✓ (green)
Floor insulation (suspended floor)	£800 - £1,200	£ 73	E53	✓ (orange)
Increase hot water cylinder insulation	£15 - £30	£ 94	D56	✓ (green)
Low energy lighting for all fixed outlets	£70	£ 49	D58	
Heating controls (room thermostat and TRVs)	£350 - £450	£ 108	D62	✓ (green)
Replace boiler with new condensing boiler	£2,200 - £3,000	£ 314	C72	✓ (orange)
Solar water heating	£4,000 - £6,000	£ 46	C74	✓ (orange)
Replace single glazed windows with low-E double glazed windows	£3,300 - £6,500	£ 86	C77	✓ (orange)
Solar photovoltaic panels, 2.5 kWp	£5,000 - £8,000	£ 284	B85	✓ (orange)

Figure 11, EPC recommended measures. Source: W-Y-P Gledhill, 2015

At the top of page three are the recommendations for energy efficient improvements in the dwelling. A breakdown of the recommended measures is presented, along with a range of estimated costs, savings, and how much each measure could improve the property's energy efficiency rating. The recommended improvements shown in order of importance, and the energy efficiency improvement figures are based on the assumption, or the recommendation, that the householder makes improvements in that order. This will be discussed with relevant literature later in this chapter. In the figure above, a broad range of improvements are recommended by the EPC's software model, starting with the most expensive measure of them all, and ending with the second most expensive measure. Again, there is literature relevant to this which will be discussed later in this chapter.

2.2.10 Alternative measures

Alternative measures

There are alternative measures below which you could also consider for your home.

- Biomass boiler (Exempted Appliance if in Smoke Control Area)
- Air or ground source heat pump
- Micro CHP

Figure 12, EPC alternative measures. Source: W-Y-P Gledhill, 2015

The next section lists other measures that can improve the energy efficiency of the property. Although there is less information about potential costs and savings, because these measures are more bespoke, and may take more time and resource to research, and install (EST, 2019).

In the figure above the EPC is recommending innovative heating technologies like an air source heat pump or a ground source heat pump.

2.2.11 EPC Page 4

11, Grosvenor Park, , , YORK, YO30 6BX
11 February 2019 RRN: 0618-9041-7292-5331-7944 **Energy Performance Certificate**

About this document and the data in it

This document has been produced following an energy assessment undertaken by a qualified Energy Assessor, accredited by Elmhurst Energy Systems Ltd. You can obtain contact details of the Accreditation Scheme at www.elmhurstenergy.co.uk.

A copy of this certificate has been lodged on a national register as a requirement under the Energy Performance of Buildings Regulations 2012 as amended. It will be made available via the online search function at www.epcregister.com. The certificate (including the building address) and other data about the building collected during the energy assessment but not shown on the certificate, for instance heating system data, will be made publicly available at www.opendatacommunities.org.

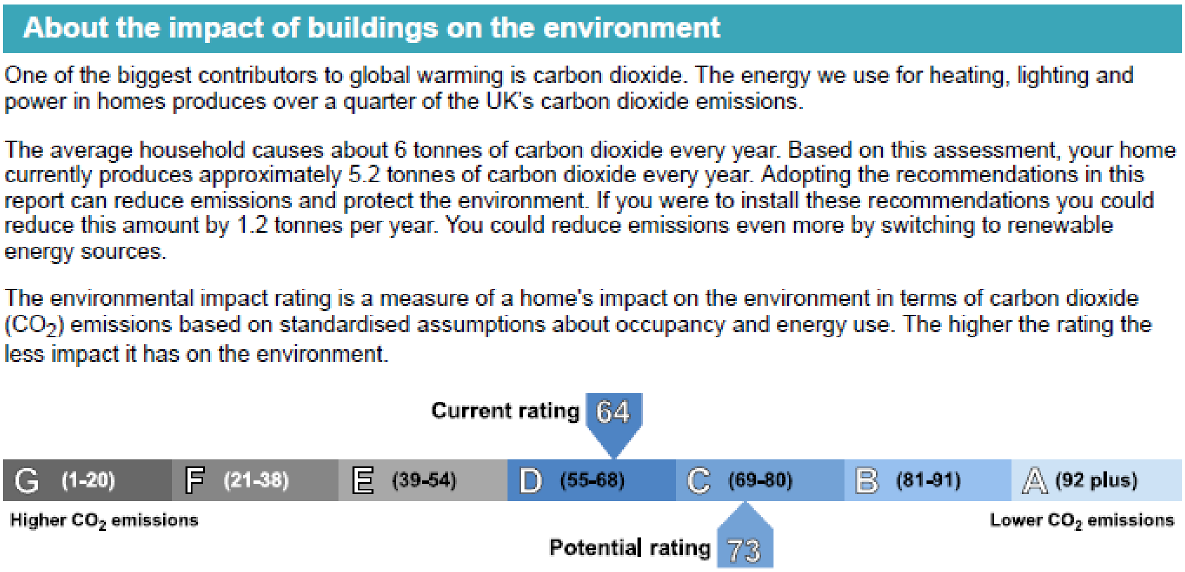
This certificate and other data about the building may be shared with other bodies (including government departments and enforcement agencies) for research, statistical and enforcement purposes. Any personal data it contains will be processed in accordance with the General Data Protection Regulation and all applicable laws and regulations relating to the processing of personal data and privacy. For further information about this and how data about the property are used, please visit www.epcregister.com. To opt out of having information about your building made publicly available, please visit www.epcregister.com/optout.

Assessor's accreditation number:	EES/006272
Assessor's name:	Mr. Toby Gledhill
Phone number:	01924 249970
E-mail address:	toby@w-y-p.co.uk
Related party disclosure:	Residing at the property

There is more information in the guidance document *Energy Performance Certificates for the marketing, sale and let of dwellings* available on the Government website at: www.gov.uk/government/collections/energy-performance-certificates. It explains the content and use of this document, advises on how to identify the authenticity of a certificate and how to make a complaint.

Figure 13, EPC's author. Source: W-Y-P Gledhill, 2019

The EPC's final page begins with basic information about the EPC, including the date of assessment, the assessor and their accrediting body.



About the impact of buildings on the environment

One of the biggest contributors to global warming is carbon dioxide. The energy we use for heating, lighting and power in homes produces over a quarter of the UK's carbon dioxide emissions.

The average household causes about 6 tonnes of carbon dioxide every year. Based on this assessment, your home currently produces approximately 5.2 tonnes of carbon dioxide every year. Adopting the recommendations in this report can reduce emissions and protect the environment. If you were to install these recommendations you could reduce this amount by 1.2 tonnes per year. You could reduce emissions even more by switching to renewable energy sources.

The environmental impact rating is a measure of a home's impact on the environment in terms of carbon dioxide (CO_2) emissions based on standardised assumptions about occupancy and energy use. The higher the rating the less impact it has on the environment.

Figure 14, EPC estimated impact on the environment: the 'EI scale'. Source: W-Y-P Gledhill, 2019

It concludes with some information about the environmental impact of the dwelling. This shows the estimated carbon emissions from the property under typical use, compares them to a notional 'average' dwelling (BRE, 2012), and illustrates how much they could be reduced by if energy efficient improvements are made.

A scale showing current and potential Environmental Impact (EI) ratings is shown, again with higher scores representing the more efficient buildings.

2.2.12 A summary of the EPC's contents

To summarise, the Energy Performance Certificate provides a record of the energy efficiency rating of a building, on a scale from A to G. It will recommend improvements that could increase the energy efficiency of the property. In order to meet current building regulations (at the time of writing), new homes are mostly (though not exclusively) rated either A or B, but older homes can be rated anywhere along the scale, dependent on their age and whether or not improvements have been undertaken in the past. In 1996, the average rating in the UK was E, with a SAP score of 46 (DCLG, 2016). Twenty years later in 2016, the average rating had moved up to band D, with a SAP score of 62 (MHCLG, 2016). Even throughout the course of this research, ratings can be seen to rise further: three years after the 2016 figures, the average score had moved up again by a single SAP point to 63 (MHCLG, 2019) (SAP scores will be discussed later in this chapter). Energy Performance Certificates are needed whenever a residential property is newly built, or an existing residential property is sold or rented (with a very small number of exceptions, such as listed buildings or properties in a conservation area where energy improvement requirements would ‘unacceptably alter’ the property’s character or appearance) (DLCG, 2014).

In summary, as can be seen from the screen captures in the section above, the EPC report itself contains:

- information about a property’s energy use and typical energy costs
- recommendations about how to reduce energy use and save money

A full sample EPC is provided in Appendix A, but again to summarise, the EPC displays:

- An estimation of energy costs of the property over a three-year period based on ‘standard occupancy’, which is based on a) current costs of lighting, heating and hot water, and b) potential costs and savings over the same period if the list of recommended improvements are made.
- Provides an energy efficiency rating (current and potential). For example, 'E and with improvements, the property could meet band C'.
- Lists actions that can be taken to improve energy efficiency and make savings, such as increasing loft insulation or installing cavity wall insulation.
- Estimates the approximate cost of these measures and typical savings of each.
- Summarises in brief the property’s energy performance-related components, such as walls, roof, floor, windows, main heating and controls, secondary heating, hot water and lighting.
- Lists key recommended measures, indicative costs; typical savings per year, and predicts a rating that may be applicable to the property after improvements have been made.
- Provides an Energy Efficiency (EI) score. This estimates the carbon dioxide emissions and also predicts a potential rating if improvements are made.

As a first step, understanding the EPC's background, and what is presented in the EPC is vital for this research, because the impact of EPC variability can only be fully comprehended after the EPC itself is understood both in its context and with regard to its contents.

Having covered the EPC's background and contents in brief in this early section, the literature review will continue by looking at the software model that *drives* the EPC. This background to what the EPC is and how it is created is necessary to understand variability, and may best sit at the beginning of the literature review before the narrative broadens to look at the EPC in the context of how energy is consumed in buildings, and how it drives UK residential energy policy.

2.3 THE EPC SOFTWARE MODEL: SAP and RDSAP

2.3.1 Background to this section

For the research, it is necessary to understand how the EPC is created in order to understand how variation can manifest. More specifically, the reader must have a reasonable understanding as to how the various scores, estimates, and recommendations recorded in the previous section are generated. Some discussion about the software model, or 'engine' behind the EPC is therefore held in this section, and this is followed by a discussion of the literature which criticises the model.

2.3.2 What is SAP?

The method of calculating energy use within a dwelling is the Standard Assessment Procedure (SAP) and the Reduced Data version (RdSAP). SAP was developed by the Building Research Establishment (BRE) for the Department of the Environment in 1992 (DoE, 1992), as a standardised tool to help deliver its energy efficiency policies. The SAP method is based on the BRE Domestic Energy Model (BREDEM), which provides a framework – a complex calculator essentially, for estimating the energy consumption of dwellings. BREDEM was developed in the early part of the 1980s, as a single zone building physics model with averaged weather conditions over seasons (Uglow, 1981). In 1986 this was further developed into a two-zone model (allowing for two internal temperature set points) with degree-day calculations used as a more accurate input of external conditions (Henderson and Shorrock, 1986). The development of the BREDEM tool is still ongoing, with the latest update being issued in 2012, and at the time of writing, further updates are due imminently after empirical testing of building components to verify the accuracy of assumptions (in relation to the thermal values of walls) made within the RdSAP model, which have recently been completed by the Building Research Establishment (BRE, 2018). However, many of the calculations and assumptions in BREDEM have been brought into RdSAP and SAP methodologies, and still exist unaltered in their original form. Many of these calculations and assumptions are called into question by academics and professionals alike, including under the remit of the BRE's SAP Scientific Integrity Group (SAPSIG, 2020), where annual or biannual meetings are held by the panel of nine members with academic and commercial backgrounds, and discussion regarding the integrity, coherence and impartiality of SAP are held. Meetings like this, leading on, or consulting on proposed changes to the model could in theory affect the EPC's rating of a property, notwithstanding any human input or error.

For example, Rye (Rye, 2015) discusses shortcomings of the RdSAP model in relation to solid wall thermal performance assumptions in RdSAP, which may have triggered the research undertaken by the BRE noted above, and ultimately lead to the imminent changes in RdSAP's assumed thermal values of walls: an interesting example of academic – practical interaction. She and her colleagues measured the in-situ U values of 78 solid walls at residential buildings throughout the country and enlisted the help of Dr Paul Baker of Glasgow Caledonian University (Baker, 2011) when she discovered he was undertaking a similar study. Both, initially independently of one another, found RdSAP's assumed values recorded solid walls with a far inferior energy efficient status than was actually the case. This served not only to provide an EPC which would not accurately reflect the dwelling's energy efficient status, but also to overstate the benefits of insulating the walls, as they would be 'brought up', or thermally improved from an artificially low level. In the interest of bounding the discussion, the RdSAP model's shortcomings are not discussed in great depth here, other than to note that any variability attributed to the energy assessor could be accentuated if the defaults within the model itself were found to be inaccurate. This is discussed in Chapter 4 of the research, where assertions are made by interviewees that the model's shortcomings are widely known, and even potentially exploited. In addition to studies by Rye, and Baker, there is some considerable literature about the RdSAP model and its shortcomings (Francis et al., 2014, Stevens and Bradford, 2013) but this sits at the periphery of the study remit, and could form a study focus of its own with considerable depth. It is, however, important to understand how RdSAP works, prior to moving on to the study's methodological and case study chapters.

2.3.3 How SAP works

SAP works by assessing how much energy a dwelling will consume when delivering a defined level of comfort and service provision. The assessment, as noted in the earlier section, is based on standardised assumptions for occupancy and behaviour. This is primarily the reason why this research makes a distinction between energy use and energy demand, the former of which falls within the study boundary, the latter outside of it. Standardising occupancy and behaviour may be seen as a significant criticism in many respects: ignoring an input that is likely to vary widely from one otherwise identical dwelling to the next, will leave a model incapable of estimating energy demand with any confidence (Sousa et al., 2017). This is because variables such as occupancy levels, occupant age, state of health, number of, and use of household appliances owned etc. will be ignored. Of key importance however, standardising demand does enable a like-for-like comparison of dwelling performance. In addition, related factors, such as fuel costs and emissions of carbon dioxide (CO_2), can be determined from the assessment, and related like for like from one property to the next. The resultant Energy Performance Certificate (EPC), created using SAP and RdSAP, presents the householder with an overview of dwelling energy efficiency, including dwelling fabric and anticipated energy use (based on standardised occupancy/demand), generating a SAP and Energy Impact (EI) score. The EPC created using SAP, and those created using RdSAP, are presented in the same way. SAP quantifies a dwelling's performance in terms of energy use per unit floor area, a fuel-cost-based energy efficiency rating (the SAP rating) and emissions of CO_2 (the Environmental Impact rating) (BRE, 2012). These indicators of performance are based on estimates of annual energy consumption for the provision of space heating, domestic hot water, lighting and ventilation, which are upgraded in the software model periodically. Other SAP outputs include estimates of appliance energy use, the potential for overheating in summer and the resultant cooling load. Despite popular belief, SAP and RdSAP do not estimate building energy efficiency per se, but instead attempt to estimate the cost-effectiveness of energy efficiency measures (Rye, 2015). As noted earlier, in Appendix A an example of an Energy Performance Certificate is provided.

2.3.4 Summary and introduction to the next section

The next section looks at what criticisms there have been of the EPC from a building physics perspective (put simply, the software model's appraisal of a building, rather than the user's appraisal). For this, it may be useful to categorise the EPC's current role with two basic functions. Succinctly, EPC outputs are used on a dwelling-specific level to inform the householder, ratify the appropriateness of energy efficient improvements and calculate the likely effectiveness of these improvements (Sousa et al., 2017). Secondly, EPC outputs are published en-masse and used as a measure for the nation's current residential energy efficient status. The two functions are not wholly distinct, because high level data is collected from the second function noted here in order to feed into the first, but these functions are distinct in their initial aims, and while themes develop and combine throughout this research, they may be discussed separately at this early stage for the purpose of clarification.

2.4 CRITICISMS OF THE EPC MODEL

2.4.1 Generalised reporting

The primary function of the EPC was initially (and may still be considered to be) to 'enhance the role of building energy efficiency for all buildings sold and let; use the SAP rate as a trigger for improving the energy efficiency of buildings; and introduce minimum SAP rates into the building regulations for the construction of new buildings' (Kelly et al., 2012). In addition to the SAP scale noted above, which may be considered the primary indicator of the EPC, the certificate also includes an 'Environmental Impact' (EI) rating (see Figure 15 below) and information on the estimated running costs of the building broken down by service type.

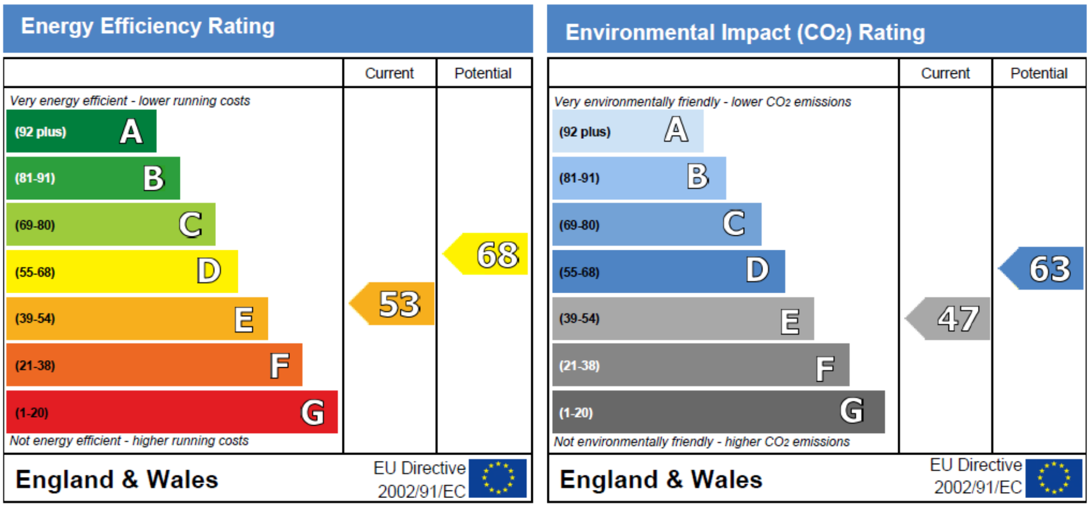


Figure 15: The SAP and EI scores on an Energy Performance Certificate. Source: W-Y-P Gledhill 2009

Average building performance of all UK dwellings is also included (at the time of writing in 2019 this is Band D, although shown as Band E on this 2008 extract) but such information may not be considered particularly helpful, because different building archetypes (or categories of dwelling) perform very differently (MHCLG, 2017)

About the building's performance ratings

The ratings on the certificate provide a measure of the building's overall energy efficiency and its environmental impact, calculated in accordance with a national methodology that takes into account factors such as insulation, heating and hot water systems, ventilation and fuels used. The average Energy Efficiency Rating for a dwelling in England and Wales is band E (rating 46).

Figure 16: information from the EPC including average rating for a dwelling in England and Wales, presented on all EPCs. Source: W-Y-P Gledhill, 2009

For instance, a circa 1930 constructed detached house with high ceilings and a large floor/wall area would perform poorly in comparison with a mid-terraced bungalow of the same age, by virtue of the increased volume of internal space there is to heat, and the increased surface area of wall through which heat will be lost. If the average performance of a building *in the same building category* (i.e., same building type, age and construction material) were given instead, as is the case in Germany (Andaloro et al., 2010), it may serve to provide occupiers, or prospective purchasers a better indication as to whether their property was over or under-performing for that particular building category. Such an addition might in turn lead to more attention being paid to this scale, and consequently, increased uptake of energy efficient measures. The certificate would also then represent a more tailored, dwelling specific form with this addition.

In Bonfield's 2016 review of housing and energy efficiency (Bonfield, 2016) he makes a similar criticism of the EPC, where he notes that assessments do not consider fully the suitability of a particular measure for an individual property when making recommendations. He elaborates further that proposed heating and insulation measures, even when superficially specified appropriately, do not take into account the interaction between existing building components or other proposed measures. Bonfield puts this down to a need to reduce assessment costs and suggests more is needed to ensure they are done in a consistent and accurate way. These comments are wholly consistent with the focus of this research.

2.4.2 RdSAP default assumptions

Ahern (Ahern and Norton, 2020) investigated the effect of RdSAP default data on dwellings in Ireland where energy efficient improvements are recommended. They explain how the EPC overstates the benefits attributable to the improvements and describe this as a 'prebound effect'. The default assumptions of RdSAP populate the EPC's inputs where information is not/cannot be collected by the DEA, and these are set at the levels which would have applied when the dwelling was originally built. These, Ahern argues, are unrealistic, primarily because most dwellings - especially older dwellings - have been improved since construction. Figure 17 below shows Ahern's modelled dwelling payback period using EPC data pre-installation (of energy efficient measure/s) such as loft insulation. It can be seen that where RdSAP defaults are used, the payback period is reduced markedly, but where they are not, the EPC's predictions are deemed quite robust. Clearly then, any extrapolated data measuring the benefits of insulation for householders – or potentially worse still calculating income for installers based on tonnes of carbon saved (see Section 2.5.5 regarding the Energy Company Obligation) – could have serious financial and political consequences.

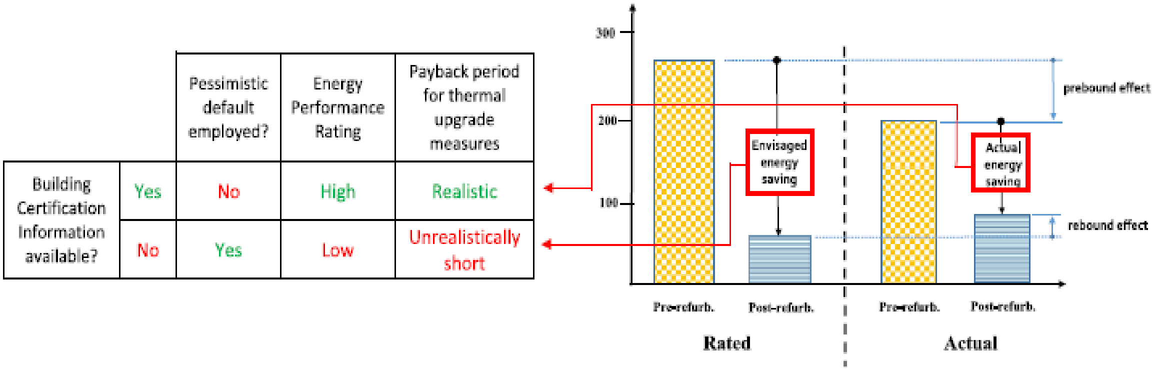


Figure 17, showing the reduced payback (hence increased effectiveness) of retrofitted energy improvements when an EPC has automated default assumptions within it, in contrast to an EPC where the DEA has collected all necessary information, and no defaults are used. Source: Ahern and Norton, Energy & Buildings, 224, 110229, 2020

Ahern recommends an alternative default to overwrite RdSAP defaults: a 'stochastically based' calculation, which has been calculated as an average of known data about a sample of properties investigated during the study. Limitations are made explicit – the sample is not large or particularly heterogeneous, and larger and more varied samples will bring about more reliable data, but their recommendations for RdSAP default overwrites may be considered compelling. Gledhill (Gledhill et al., 2016) undertook a hypothetical study four years earlier with the same focus. An EPC at a notional dwelling had known data replaced with RdSAP defaults, to measure variation. A 'rounding down' effect was established and discussed. Gledhill discussed the same implications as Ahern, albeit with less robust evidence, but went further, to discuss the potential for DEAs to latch on to the effect of these RdSAP defaults and potentially manipulate data against desired outcomes. This early study by Gledhill, which feeds into this research, fed into the DEA interviews which form the first part of the case study for this research. In the interests of bounding the discussion at this stage to the RdSAP model alone, the results are discussed in the case study chapters and conclusion.

Gonzales-Caceres (Gonzales-Caceres and Vic, 2019) also found problems with RdSAP's default assumptions when they undertook a study looking at how to improve the recommended list of measures on the EPC. They studied a timber framed residential building in Norway, looking specifically at improving the RdSAP (and other energy efficient software model) assumptions in respect to wall U-Value, air tightness and ventilation. They found areas for improvement over automated defaults, though these were achieved with use of an infra-red thermal imaging (IRT) camera, and an air flow measurement device. Physically measuring air tightness, ventilation and wall U values in each building is likely to add to costs, and the time required to undertake the inspection. This could be a useful additional measure to adopt where retrofit is of key importance to the EPC inspection remit, as might the schedule of rates mooted by the author. This may be an interesting area for further investigation, but in the interest of bounding the research, there is no further discussion here on the EPC Recommended Measures section.

2.4.3 Smart metering and the EPC

Crawley (Crawley, Hardy and Glew, 2019) suggests that uncertainty in published RdSAP scores may be recorded on the EPC itself. Crawley makes the case for the use of smart meter data, and asserts that a margin of error may be more accurately predicted (a mean 15% uncertainty is posited) with this. Crawley's study into the effectiveness of smart meters for measuring building thermal performance focuses on the measuring of a heat transfer coefficient (HTC) and a heating power loss coefficient (HPLC), both of which can in theory yield useful results in combination with smart metering. Sakuma (Sakuma et al., 2019) undertake a similar study using sensors and air monitoring equipment, however Crawley notes that a number of barriers must be overcome for accurate reporting to be achievable: notwithstanding issues with data protection and standardising collected data to eliminate the influence of the occupant's own use of the dwelling, in respect of the building fabric, questions are raised about the extent to which solar gain may affect heat loss, and the impact of the location of heating appliances. Also, heat 'bleed', into neighbouring buildings cannot be easily accounted for. Crawley notes that RdSAP is not sophisticated enough to account for this. The specification of the heating appliances (i.e., how efficient they are) is not actually mentioned in Crawley's paper, but is noted later in this research (during analysis of EPC data in Chapter 5) as a significant component in accurately measuring a building's overall thermal performance. However, if recommendations as to how to retrofit effectively are to be made, building components would still need to be identified, and the EPC may therefore sit alongside smart metering, rather than be replaced by it, in order to provide a full picture of the dwelling, its thermal efficiency, its characteristics, and how best to make improvements.

This study will not elaborate further on energy supply, for two reasons. Firstly, energy demand, as noted above, is a complex area well worthy of its own study, and a literature review that may be devoted entirely to it: in the interests of bounding this research, this is left outside of its scope. Secondly, the SAP model makes standardised assumptions about the cost and quantity of energy supply which are in themselves a matter for some criticism (Sakuma et al., 2019, Sousa et al., 2017) but given with the aim of being able to make 'like for like' building fabric comparisons (BRE, 2009). While shortcomings in this respect are noted here, to come back to the research, it is the EPC *and its user*, the domestic energy assessor (DEA) that form this study's focus.

2.4.4 New building and the EPC

The Zero Carbon Hub's 'Closing the Gap' report (Zero Carbon Hub, 2013) into the energy efficiency of new-build housing undertakes a thorough and wide-ranging study into the performance gap noted between 'designed', and 'as built' dwellings. This study uncovered a range of issues, with findings then attributed to four broad categories: 'no immediate action, 'retain a watching brief', 'priority for research' and 'priority for action'. This categorisation process was described as a 'prioritisation matrix'. In separating and allocating findings into one of these categories, a simple breakdown of priorities was ascertained, for which appropriate action could then be taken. Whilst this forms only a very brief overview of a complex study with some considerable depth, and the study was undertaken into the performance gap between designed and newly built property only, the purpose of its inclusion at the start of this literature review is to highlight the themes that cut across to this reseach focus. Within the section of the prioritisation matrix of the Zero Carbon Hub study entitled 'priority for action', the following themes were included:

- concern over competency of assessors
- limited understanding of design decisions on energy performance
- inadequate understanding and knowledge
- inadequate consideration of skills and competency at labour procurement
- concern over consistency of some test methodologies and interpretation of data

- lack of robust energy performance related verification – reliance on third party information

The Zero Carbon Hub priorities for action are considered relevant here because they bring up very similar issues to those of the interviewees in this study (which are discussed in Chapter 4). However the focus is a performance gap rather than variability and so the context is not the same, and the assessment process for new build is that of SAP as opposed to RdSAP; while one is derivative of the other these too are not the same, but the themes of competency, consistency, understanding, knowledge, as well as systems of procurement and verification/auditing are very closely aligned with those which arise from the DEA interviews (Chapter 4) and the test EPCs (Chapter 5). This is expanded in the discussion sections of the next chapters, and in the research conclusions. These are all themes that arise within the remit of the research here, as well as that proposed on existing dwellings within the conclusions to this research to varying degrees, and hence the study is considered relevant to the research.

With such slow growth of new build housing stock, it is the transformation of the nation's *existing* building stock which may be considered essential. While notable in terms of framing the wider research area, consideration of new build housing stock in the UK is an area worthy of considerable further investigation, but must lie largely beyond the remit of this research.

2.4.5 Summary of Section 2.4

Section 2.4 has focused on some key criticisms of the EPC model, and has introduced criticisms where there may be some ambiguity about whether erroneous data is the responsibility of the model, or its user. As the chapter unfolds, the researcher moves away from the model and strikes a balance between it, and its user, whilst building context along the way. The next section will look at the policy context of the EPC, along with the extent to which the EPC is becoming more entrenched in policy. High level policy objectives stem from the United Nations Framework Convention on Climate Change (UNFCCC), including the Kyoto Protocol and subsequent Paris Agreement, and the European Energy Performance of Buildings Directive (EU Commission, 2002).

Against this backdrop it may be considered more important than ever that EPC data is accurate, and the system for producing EPCs robust.

2.5 EPCS: A POLICY CONTEXT

Since its inception just over a decade ago, policy has accommodated a significant broadening of the EPC's uses. This has extended to encompass use as a carbon calculating tool under the Energy Company Obligation (ofgem, 2012), to calculate heat output and hence subsidy for the Renewable Heat Incentive (RHI)(DECC, 2014), to form a benchmark for the subsidised installation of solar panels under the government's Feed In Tariff (FIT)(DECC, 2012), and more recently to set minimum standards for the letting of residential property under the Minimum Energy Efficiency Standard, or MEES (BEIS, 2017). In addition to these specific schemes, there is a considerable, and growing 'bank' of EPC data upon which to draw, available from a variety of locations, including that collated by the National Energy Efficiency Data Framework (NEED)(DECC, 2013), as well as via a central register for England and Wales (MHCLG, 2020), and also in the form of collated data presented by the national housing surveys, undertaken by the Building Research Establishment (BRE) in partnership with the ONS and the government department of Business, Energy & Industrial Strategy. EPC data collated en-masse like this forms an important part of this research. Through the relevant national housing surveys and the NEED, opportunities present themselves for academics, professionals and politicians to research standards and identify areas for further research or improvement, establish status, set benchmarks, and formulate policy. The ever increasing scale of EPC data may serve to proliferate both the occurrences and types of its uses.

This EPC data performs an important function for policy makers, professionals and academics, and is becoming increasingly useful as it grows from the EPC's inception, only a little over a decade ago (at the time of writing). It's growing use may reinforce the need to ensure there are high levels of accuracy. This section looks to expand on the areas around which EPCs are becoming increasingly important. The section intentionally starts broadly, so the reader can understand the context, but in the interests of maintaining relevance to the research question, the section narrows quite quickly to focus on the EPC's role within this context, all the way linking the subject matter back to the research question.

2.5.1 The broad policy context

The Intergovernmental Panel on Climate Change (IPCC) believe that to avoid catastrophic climate change we must reduce global greenhouse gas emissions by 45% by 2030, and 100% by 2050 (IPCC, 2018). In a May 2019 report, the UK government's Committee on Climate Change has revised its recommendation that greenhouse gas (GHG) emissions are reduced by 80% from a 1990 benchmark to net zero, by 2050 (Committee on Climate Change, 2019). This recommendation has been adopted, and in the government's Energy White Paper (BEIS, 2020), which draws much of its information on buildings from EPC data, there is confirmation of this 2050 objective. The same White Paper marks buildings as the second largest UK sector responsible for emissions after transport, and ahead of power, industry and natural resources. The Energy White Paper reinforces the IPCC's assertion that, 'rapid, far-reaching and unprecedented changes', are needed, including to systems of production and consumption in the global economy. The recognition of a climate emergency forms an increasing focus of the media and in recent years the focus has intensified notably. The term 'climate emergency' itself was not in widespread use at the start of this research, with Gills describing recent domestic political efforts thus far as a 'successful failure' (Gills and Morgan, 2019). It may be fair to assert that the term is now frequently coined.

While newly built housing stock during the year ending June 2019 reached an 11 year high of 173,660 (MHCLG, 2019) in the UK, this still represents an annual increase of well under 1% of the UK's total housing stock (MHCLG, 2020) and means that proposed changes to the way we build new homes will make very little impact on energy use within the domestic sector as a whole, at least over the short to medium term. Zero carbon was proposed by the UK government in a revision to Part 1A of the building regulations from 2016, four years earlier than the European requirement under the EPBD (Energy Performance of Buildings Directive) in 2020, although this has since been revised to fall in line with the EU EPBD (at least at the present time; any intentions to diverge with EU policy following Brexit are not yet clear at the time of writing). In addition, the Code for Sustainable Homes – a method for assessing and certifying sustainable design and construction, has been withdrawn. Nevertheless, increasing demands on house builders in respect to the energy efficiency of a new domestic dwelling, coupled with the UK's 2016 vote to leave, and subsequent departure from the European Union, along with uncertainty about the future relationship with the EU and recovery from the Covid19 pandemic, growth of the new build sector may be slow or inconsistent, at least over the short term. This in turn could mean minimal inroads into policy issues including climate change and fuel poverty although the Kyoto agreement does still bind the UK regardless of its membership with the European Union, and fuel poverty is by its nature an important consideration for any domestic government.

2.5.2 Retrofitting existing housing stock: the 'retrofit agenda'

Having bounded the research focus to existing housing stock only, the challenge of improving existing housing stock has a number of facets. Residential energy consumption is a complicated issue, related to a number of factors including the physical attributes of the homes in which people live, the electrical systems or appliances they use, as well as the occupant's behaviour (Jenkins et al., 2017; Swan et al., 2010; Yao and Steemers, 2005). To increase complexity yet further, one can add in fuel prices and inflation (Kavgic et al., 2010). For any nation's decision makers, it may be considered very challenging to bring all of these factors together and address them for the purpose of creating effective energy policy. However, the focus in this research is primarily that of assessing a property's energy efficient status by the assessor, and the resultant information produced, and the next section reviews this within the policy-related, economic and social context in the UK that frames the issue. An integral part of this context is the ability to be able to measure the energy efficiency of an existing building (a residential building for the purpose of this research) accurately and consistently, so that progress against targets can be measured and current carbon emissions can be calculated.

2.5.3 Government reporting of EPC data

2.5.3.1 The EPC Register

Communities and Local Government manage a national ‘EPC Register’, which holds all EPCs in England and Wales for public access (available here: https://find-energy-certificate.digital.communities.gov.uk/). This may be regarded as a useful source of information, with over fifteen million EPCs held at January 2020 (MHCLG, 2020). This data is accessible to academics, politicians, and professionals, and may be used for all manner of different activities, including individual dwelling appraisals, scrutiny en-masse for statistical purposes, or for policy or benchmarking.

2.5.3.2 The English Housing Survey

A key driver behind the BREDEM and SAP models, discussed earlier in this chapter, is the information obtained from the government’s English Housing Survey. This is a continuous national survey commissioned by the current Ministry of Housing, Communities and Local Government (MHCLG), as well as earlier incarnations of the same department. In England, the survey began in 1967, and has just passed its 50th year at the time of writing. In 2018, approximately 13,300 households took part in face-to-face interviews, and a further 6,000 homes had a physical survey undertaken (MHCLG, 2019). The survey covers all housing types and tenures and provides information and evidence to inform development and monitoring of housing policy, not just within MHCLG, but across other government departments, in particular the Department for Business, Energy and Industrial Strategy (BEIS). Results of the survey are published annually and are available to all. As such, results may be used by a wide range of public and private users, including academics. While in total the survey covers issues such as household composition, ethnicity, length of residence, income, housing expenses and attitudes toward the local area within interviews, and housing condition and disrepair along with health and safety are covered within the physical surveys, the energy efficient status of the property forms a big part of the physical survey, and fuel costs are covered within the interviews (MHCLG, 2017). Each year, the EHS produces a separate report on energy efficiency in the English housing stock. The 2016 report (MHCLG, 2017) discusses the improvement in average RdSAP rating since 1996 (RdSAP may be described as the calculator, or software model which drives the EPC which is discussed earlier in this chapter), which properties typically fare worse on EPCs and why, which tenure of property typically fares worse when assessed for energy efficiency, and what energy efficient and heating measures have been installed to the housing stock since

1996, as well as what effects this has had on the stock picture as a whole. This data drives policy and is based entirely upon the EPC process. This is because while no actual EPC is lodged on the EHS programme, the same calculator – the RdSAP calculator – used to create the EPC is used (MHCLG, 2017). As such, accurate and consistent measurement and recording of data is vital if a reliable assessment of our housing stock's current status is to be obtained, and meaningful policy decisions are to be made with achievable goals put in place.

2.3.5.3 The HEED and NEED

EPC data is presented elsewhere for the purpose of helping government bodies and private organisations plan, monitor and deliver progress on programmes that improve the energy efficiency of buildings. The Homes Energy Efficiency Database (HEED) is run and managed by the Energy Saving Trust (EST) (Energy Saving Trust, 2019). Those publicised by the Energy Saving Trust as having access to HEED are central and local government, organisations contracted by any local or central government agency to carry out domestic energy efficiency related projects, universities, community groups and non-profit organisations. The databases available contain information about dwelling characteristics, heating systems, insulation levels and type, and microgeneration. The information is compiled from historic energy efficiency schemes and includes EPCs generated during these programmes. To reiterate then, with such a broad spectrum of potential users, it is important that the EPC data these users are accessing is robust.

The National Energy Efficiency Data Framework (NEED) (DECC, 2013) was set up to provide a better understanding of energy use in domestic and non-domestic buildings in Great Britain. The datasets match gas and electricity consumption data, collected by the (now) Department for Business, Energy & Industrial Strategy (BEIS) with information collected on energy efficiency measures installed in homes, from the HEED, discussed above, along with other energy efficiency programmes such as the Energy Company Obligation, Feed in Tariff, and (now largely defunct) Green Deal, all of which are discussed in the next sections. The NEED, while focusing primarily on energy consumption as distinct from energy efficiency, holds within its reporting figures based on assumptions that are underpinned by the EPC engine: RdSAP.

2.5.3.4 MHCLG Energy Performance of Buildings Certificates

Finally, EPC data is collated by the Ministry of Housing, Communities and Local Government (MHCLG). These are compiled quarterly into reports that scrutinise various trends, including dwelling floor areas, estimated heating, hot water and lighting costs (given based on the EPC's model, or calculator which is presented at this chapter's outset) the EPC's score (the RdSAP rating, also discussed at the introduction to this chapter), and the EPC's environmental impact score (EIR – again also discussed at the start of this chapter). These quarterly reports are published on the MHCLG's website (MCHLG, 2019) and available for public access. Clearly if there is variation, this will be carried over into the published figures.

2.5.4 Residential energy efficiency improvement schemes in the UK

2.5.4.1 Overview of schemes in the UK

The core function of the EPC data published on the MHCLG's website, noted above, may be to inform future energy policy. Historically, there have been a wide range of policies that impact upon domestic energy consumption reaching back to the first oil crises in the 1970s (Mallaburn and Eyre, 2014). However, in the interest of limiting the scope to an appropriate level, this research will look at more recent policy, which is directly focused on existing residential housing stock, covering the ECO, Green Deal and its most recent predecessors, the Community Emissions Reduction Target and the Community Energy Saving Programme (ofgem, 2014). It should be noted that there are a number of other policies that had a direct impact on the energy efficiency of the housing stock, such as Decent Homes for social housing (National Audit Office, 2010), which affected 1.4 million homes, and Warm Front (Warm Front Team, 2011) which led to more than 2.3 million domestic property upgrades. However, these schemes were not directly underpinned by energy performance data or carbon savings during the decision-making process and are therefore touched upon over the course of the next few paragraphs. They are here only to contextualise the development of energy efficiency related policy.

Utility supplier obligation schemes that are delivered by the Government are supported by the Office of Gas and Electricity Markets (ofgem). They are a UK Government department, and an independent National Regulatory Authority. This department has overseen energy supplier obligation schemes that have underpinned much of the UK's energy policy in the sector (Rosenow, 2012).

2.5.4.2 The CERT & CESP schemes

Under the current Energy Company Obligation's most recent predecessor, the supplier obligations were the Carbon Emissions Reduction Target (from April 2008), and the Community Energy Saving Programme (from April 2009), both of which expired in December 2012 (ofgem, 2013). For CESP, the UK Department of Energy and Climate Change (DECC) set an overall carbon emissions reduction target of 19.25 million tonnes of carbon dioxide (Mt CO_2). This was to be met by requiring gas and electricity suppliers and electricity generators to deliver energy saving measures to domestic consumers in specific low-income areas. This obligation was placed on all licensed gas and electricity suppliers that had at least 50,000 domestic customers and all licensed electricity generators that had generated on average 10 TWh/yr or more over a specified three-year period. CESP was designed to promote a 'whole house' approach, treating the property as a whole system by considering the interrelationship of improvements (Jones et al., 2013) and to treat as many properties as possible in defined geographical areas that were selected using the Indices of Multiple Deprivation (IMD) in England, Scotland and Wales. In England, the lowest 10 per cent of areas and in Scotland and Wales, the lowest 15 per cent of areas qualified. Consequently, CESP contributed to the Government's Fuel Poverty Strategy of the time (Boardman, 2010). Energy companies achieved 16.31 Mt CO_2 of the 19.25 Mt CO_2 target, or approximately 85% of the target (ofgem, 2013).

For CERT, gas and electricity suppliers that generated power above a certain pre-designated level (of 10 TWh/yr or more over a three-year period), had to achieve targets for reducing carbon emissions within domestic properties (Jenkins, 2010). For this scheme, the targets were much higher: an overall target of 293 Mt CO_2 was to be achieved. This was broken down into subsections, with 40 per cent of this to be within a 'priority group' (people over 70 and on certain qualifying benefits), 16.2 million tonnes of carbon dioxide savings designated to those on qualifying benefits (sometimes referred to as the ‘Affordable Warmth’ group, together with the over 70s above), and 73.4 million tonnes of CO_2 designated to professionally installed insulation measures. A total saving of 296.9 Mt CO_2 was made by the energy companies, achieved against the overall target of 293 Mt CO_2 (ofgem, 2013). Due to difficulties in measuring progress against targets under CERT and CESP, along with a perceived need to mitigate against potentially unscrupulous behaviour that was said to be taking place by installers and suppliers, albeit anecdotally (Forman, 2016; DECC, 2014), the energy performance certificate was drafted in as a key, very important part of the ECO process, which is elaborated upon below.

The carbon saved under the CERT and CESP, as well as earlier schemes was done so in a different way to the current ECO (Energy Company Obligation) (ofgem, 2013) scheme, without measuring savings for each individual property. ‘Deemed’ carbon saving scores were applied to properties (DECC, 2014) where measures were installed. For example, a three-bedroom, semi-detached house of either ‘small’, ‘medium’ or ‘large’ size, having loft insulation applied, might be deemed to save 8, 10, or 12 tonnes of carbon (over the lifetime of the installed measure) respectively, and the utility company would report it as such. This raised a number of issues, as the deemed scores inevitably missed nuances in individual dwelling types, and they incentivised installers to aim for more straightforward measures, (DECC, 2014) such as loft insulation and cavity wall insulation to regularly shaped semi-detached and detached houses in suburban areas, as opposed to hard-to-access, ‘hard-to-treat’ (Watson, 2013) cavity walls in inner-city areas. Similarly, flats and older, solid-walled terraced houses in inner city areas were also overlooked, also being considered difficult in comparison with those post-war suburban areas. The deemed scores took no account of geography throughout the UK (DECC, 2014) meaning carbon saved from a three-bedroom, semi-detached house in the warmer South, for example, would result in the same nominal saving as an identical property with the same measure applied in a colder area in the North. EPCs, it was mooted, would provide the nuance and legitimacy needed to refine this process, with individual carbon savings recorded and tailored to each property’s attributes, by a person qualified to carry out such an inspection.

Under CERT and CESP, rates for each deemed tonne of carbon were agreed between the utility company and installer, and would vary, mainly dependent on the progress made by utility companies toward targets (Nicol et al., 2014; UK's National Energy Efficiency Action Plan). This was a commercially led process, with only CERT and CESP *outputs* being carefully prescribed, leading to the easier measures being taken first. In this respect, cheaper insulation measures would be targeted by installers, meaning a high level of cavity and loft insulation measures were taken up under these schemes at the expense of more expensive and technically complex/skilled measures such as internal/external wall insulation, heating upgrades or glazing.

These varying rates, dependent upon progress toward targets, presented difficulties for installing companies as the process led to large peaks and troughs in volumes of measures installed (Ipsos Mori, 2014). This meant large numbers of redundancies or rapid and poorly planned recruitment drives based on demand. This potentially created issues for installation standards, with Ofgem reporting a 14 per cent failure rate in installation standards of technically monitored jobs throughout the scheme (DECC, 2014).

Reflecting on these schemes, as well as schemes that preceded CERT and CESP, it may be reasonable to assert that further progress at similar rates would be more costly and time-consuming to achieve, as the opportunities to install more straightforward measures, in easy-to-access properties diminish, leaving technically complex, higher skilled and more expensive carbon savings left, such as hard-to-treat cavity walls, internal and external wall insulation measures, and heating upgrades/fuel switches, presenting potential difficulties for both policy-makers and the installation industry. This is reflected in Figure 18 below, which presents the slowing rate of straightforward cavity wall and loft insulation measures following the end of the CERT and CESP schemes. Since 2013, an additional 12% of homes in total fitted with cavity wall insulation over a five-year period (equating to a total of 14.1 million of the 20.3 million homes with cavity walls), and an additional 7% of homes were fitted with loft insulation at 125mm or more (equating to a total of 16.5 million of the 25 million homes with lofts) over the same period (BEIS, 2019). As noted earlier in this section, those remaining cavity-constructed walls (the balance of the 20.3 million total) may be 'hard to treat', or otherwise more challenging to insulate, potentially leading to more costly and onerous installations, and may in part be the reason attributed to the smaller numbers since the Energy Company

Obligation's (ECO) inception in 2013. The ECO is discussed in the next section of this chapter.

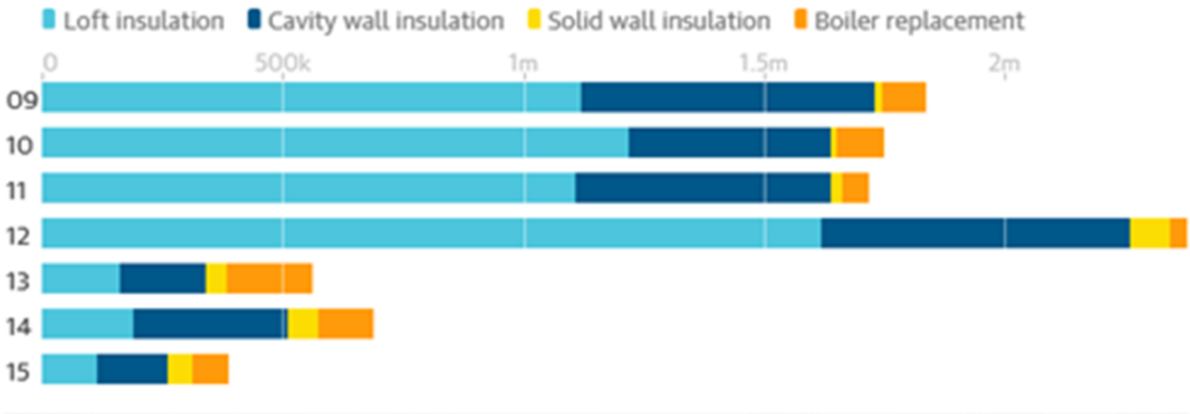
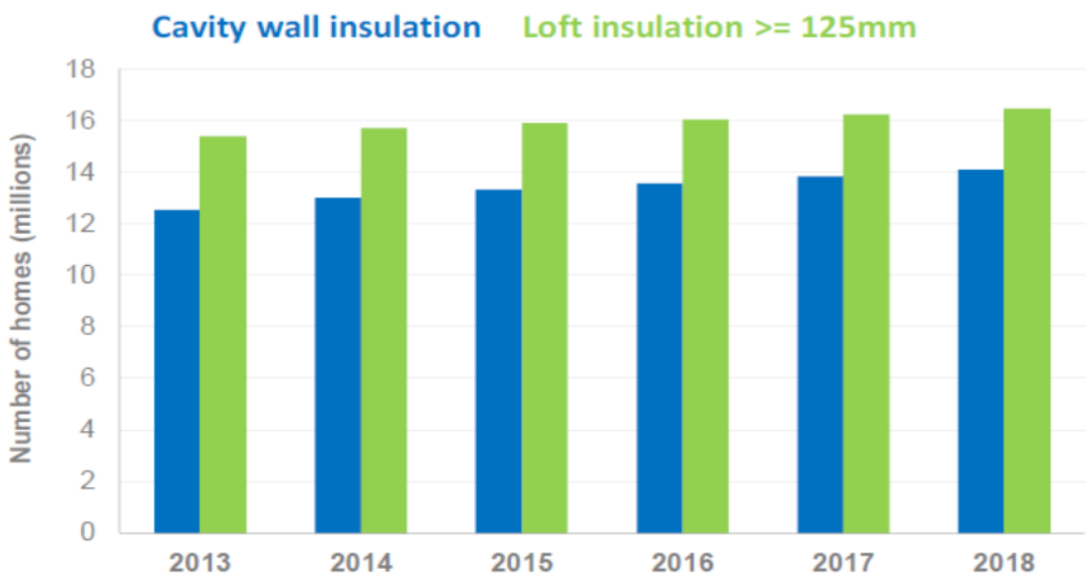


Figure 18 showing (among others) the number of loft and cavity wall insulation measures installed under CERT and CESP during the period it ran, from 2009 – 2012, then a drop in installations under ECO, from January 2013 to 2015. Source: DECC, 2016.



Insulated homes in Great Britain (Thousands)

End of year	2013	2014	2015	2016	2017	2018
Cavity wall insulation	12,550	13,010	13,320	13,560	13,820	14,090
Loft insulation >= 125mm	15,390	15,700	15,890	16,050	16,250	16,460

Figure 19, showing the number of installed cavity and loft insulation measures, from December 2013 to December 2018. In conjunction with Fig 16 above, this shows a continuation of the smaller numbers installed since the start of ECO in 2013, when compared with CERT and CESP which preceded the ECO. Source: BEIS, Household Energy Efficiency (HEE) National Statistics, detailed report, 2019.

2.5.4.3 The Energy Company Obligation (ECO)

The Energy Company Obligation (ECO), which started in January 2013, is at the time of writing in its third phase as the most recent incarnation of the utility supplier obligation, a major part of the Government's plan to reduce carbon emissions in the UK. The framework is broadly similar to that of the CERT and CESP schemes (Gooding and Gull, 2015). The ECO scheme places three separate obligations on energy suppliers: the Carbon Emissions Reduction Obligation (CERO), the Carbon Saving Communities Obligation (CSCO) and the Home Heating Cost Reduction Obligation (HHCRO)(ofgem, 2013). Each of these are met by installing measures that reduce carbon emissions, or energy bills in the case of 'Affordable Warmth' (ofgem, 2013) in the domestic residential sector. In the same way as CERT and CESP, the targets imposed on the energy companies are a reflection of their share of the market, and they are expected to meet these obligations by promoting and subsidising the measures (ofgem, 2013; Gooding and Gull, 2015).

ECO's carbon targets were 27.8 Mt CO_2 over the initial period from January 2013 to April 2015 (ofgem, 2013). These targets were initially apportioned as a 20.9 Mt CO_2 target under CERO, and 6.8 Mt CO_2 under CSCO, of which at least 15 per cent, or 1 Mt CO_2 must be delivered to rural households - the 'rural safeguard', thus ensuring that these more difficult-to-access areas are not wholly ignored, as was seen under CERT and CESP schemes. However, CERO targets were revised downwards from 20.9 Mt CO_2 to 14.0 Mt CO_2, after talks between energy companies and the Government seemed to end in agreement that the costs to achieve the initial target would be more expensive than initially anticipated, although no robust evidence was published that might support this, and so this must be considered an assertion that cannot be verified one way or another. The HHCRO targets are independent of the carbon saving targets, quantified as fuel cost savings, and a total reduction of lifetime notional space and water heating costs were set at £4.2bn by March 2015. Ofgem's September 2015 final compliance update for ECO's first phase points to these targets having been successfully achieved (ofgem, 2016).

Initially, the ECO scheme was set to run alongside the Green Deal, a scheme set aside from energy company obligations that was intended to increase uptake of energy efficient measures by providing a novel financing mechanism, in which the costs of installed measures were financed through a charge attached to a property's electricity meter (Dowson et al., 2012; Rosenow and Eyre, 2013). As part of the Green Deal, a framework of quality assurance, advice and accreditation for installers and assessors was implemented through the PAS 2030 (Forman and Tweed, 2014) (a 2019 revision has seen the department of Business, Energy & Industrial Strategy (BEIS) introduce PAS 2035, although PAS 2030 still exists in revised form: there is a distinction between the two PAS schemes, 2030 being for installer competence, while 2035 is for assessment competence (BEIS, 2019)) and the National Occupational Standards (Killip, 2013) with the aim of providing reassurance to prospective customers as regards quality and robustness of energy advice and installation. The EPC was a part of this, introduced into both the ECO and Green Deal schemes in an attempt to legitimise the processes, and provide more accurate reporting of data. The initial concept was that more expensive Green Deal measures could be installed with the help of 'top-up' ECO funding, so that a notional 'golden rule' could be maintained, whereby repayments must not exceed the amount saved in efficiencies on household energy bills over the lifetime of the measure installed, even with the installation of more expensive measures such as solid-wall insulation or glazing. However, reductions in the levels of ECO, and the relative failure of the Green Deal since its inception, has led to the Green Deal finance company's withdrawal (and hence essentially the Green Deal itself) (Parliament, UK, 2016). The Green Deal may have been underpinned with respectable intent but was ultimately not successful: it was considered too complicated and to have been badly managed (Guertler et al. 2013). From a policy perspective, the UK domestic energy efficiency position was reviewed in 2016, when the UK government commissioned a report by the CEO of the Building Research Establishment (BRE), Sir Peter Bonfield (BEIS, 2016). The review was published in December 2016, and the high-level questions were mostly consumer related, and may be broadly summarised as:

- 'Who can the consumer trust?'
- 'How can companies find the right certification?'
- 'How can consumers be certain that those operating under the different schemes are credible and can be trusted to do their work where driven by incentives of regulation?'

- ‘How can we ensure that the many different measures being installed interact with the building and each other as they should?’

The solutions to these questions, which are now being implemented, include formation of a framework combining a new quality mark and three key elements: a consumer charter; a code of conduct for companies; and codes of practice relevant to the installation of each measure (including PAS 2035). Detailed recommendations include discussion about ‘a consistent and fair redress process’, ‘impartial information and guidance’ (through a central information hub), an ‘overarching standards framework’, ‘embed core knowledge including basic building physics’, ‘an organisation to develop and oversee the quality mark’, a ‘robust and joined-up industry-wide compliance and enforcement regime’; and ‘an appropriate design stage which takes a holistic approach and adequately considers the home, its local environment, heritage, occupancy.’ The shortcomings of EPCs in informing householders and providing useful, robust information on how they might retrofit homes for improvement is touched upon in Bonfield’s report, although the conclusion drawn is that the EPC may simply be removed from the Energy Company Obligation and Green Deal assessment procedures, in favour of a reversion back to deemed (carbon) scores similar to those used under CERT and CESP, though this time based on a historic bank of EPC data.

Ofgem has been effective in recording progress against targets – tonnes of CO_2 saved or costs saved under its primary routes through the ECO – even if those targets have been revised downwards after consultation with the energy companies who pay for them. However, it is more challenging to identify societal, or demographic-related energy efficiency savings under this, or any scheme, according to Trotta (Trotta, 2018). Under ECO, the HHCRO is aimed at those on means-tested benefits and hence those more likely to be susceptible to fuel poverty (Robinson et al., 2018), but while Trotta does not mention the HHCRO obligation specifically, he argues that ECO funding has not been targeted effectively, either in specifically aiding the fuel poor, or by identifying those ‘able to pay’ (for energy efficient improvements) householders that may otherwise have taken up measures during the ECO’s programme thus far. Trotta identifies certain groups that may benefit from ECO, or aid its take up, but have not been targeted effectively to date. English households living in houses built before 1990 and with a length of residence higher than one year are more likely to invest in energy efficient retrofit measures, he asserts. His study also identifies a disparity between the willingness to engage in energy efficient retrofit measures between those owner occupiers with mortgages, and those who own outright; his justification being that those with mortgages have a longer-term interest in their properties, and less of an aversion to debt, by definition, leading them to be more likely to consider improvements that may require financing, but would typically last a long period of time. Most data, he argues, including earlier English Housing Survey reports, categorise owner occupiers in one group, and so these findings would not have been clearly identified. Linking back to the earlier section in this chapter, Trotta sources all of the information in his paper from English Housing Survey data, where the RdSAP model is used to calculate the energy efficient status of a building.

2.5.4.4 The future of residential energy policy

Future incarnations of energy efficiency improvement schemes may be better placed targeting household groups with a low retrofit uptake, such as those who live in older, solid walled properties that may be more costly or challenging to improve, or private rented properties where some considerable recent focus, in particular under the government's 'Minimum Energy Efficiency Scheme', or MEES (BEIS, 2017) - which also uses energy performance certificates - has been targeted. These, along with their relevance to, and underpinning by the EPC, are discussed later in this section. Interventions targeted at these groups of households may help to improve uptake and may also may help spread any available funds further – if willing, 'able to pay' customers are targeted, as they could contribute toward the cost of measures, for example. These latter, able to pay customers might previously have commissioned EPCs as part of a Green Deal Advice Report (Green Deal Orb, 2012) taking up the Green Deal as an aid to making improvements, but since its failure (Howard, 2015) there is currently no vehicle to help them do this (Parliament UK, 2016).

Kelly (Kelly et al., 2012) write that, using the SAP model, there has been tremendous growth in energy efficiencies of residential property since 1970, citing the data source of DECC's Domestic Energy Consumption in the UK Tables. These show an average SAP rating of residential property in the UK of 18, rising to 54 in 2010. Kelly et al make the point that continual growth at the same rate would see an average SAP rating of 88 by 2050, and conclusions are drawn from this within the body of their paper. However, a considerable number of ‘easy wins’ have been achieved over the period to 2010 under the government’s insulation programmes discussed above, including CERT, CESP, and ECO, which include loft insulation, cavity wall insulation, improved gas central heating boiler efficiencies and double glazing. Even improved central heating controls, including ‘smart’ controls have been provided under these schemes, although the data collected about their effectiveness in the government’s DEFACTO study (DECC, 2014) (Lomas et al., 2018) would suggest they are not as effective as their manufacturers have claimed. The measures required to continue the rising trajectory at the same rate are arguably more difficult and costly to achieve, such as solid wall insulation, ‘hard to treat’ cavity insulation to older properties (Swan et al., 2010), or the insulation of renewable energy measures such as solar photovoltaics (solar ‘PV’). This may go some way to explaining the ‘levelling off’ of dwelling SAP scores across the nation seen over recent years, and reported by the English Housing Survey (EHS, 2018), although a drop in new building over the same period is also likely to contribute to this (gov.uk, 2019). It could be regarded as more likely therefore that the increases in energy efficiency seen during the period from 1970 to 2010 would not be sustained at the same rate to 2050, and that steadier progress may be made, especially to the 75% of existing housing stock that is estimated to be remaining in the UK in 2050 (ECI, 2005). Accurate reporting of EPC data, such as that contained in the EHS may well be the method used to monitor this.

2.5 MODELLING EPC DATA EN-MASSE

The reporting of energy efficiency of housing stock may be considered a complex affair. According to Sousa (Sousa et al., 2017) two component parts are seen to exist: the energy supplied to the dwelling, and the energy demanded by its occupants. In terms of policy, the EU described these as ‘calculated’, and ‘measured’ methodologies, and expected each nation to adopt either one approach, or another (Crawley, 2019; European Parliament, 2010). Measured methodologies may furthermore be split into the categories of energy used, and the energy lost via transformation. The development of a housing stock energy model that will enable reporting of energy efficient status may be seen as challenging in this context. The key challenges are, according to Sousa, to record the physical attributes of the building (for example its size, shape and building fabric), the components within it (fuel, water and space heating appliances, insulation levels) for energy calculation, and also – essential if calculating energy demand – occupancy and use (household make up, patterns of use, behaviour). Household behaviour is a known area of modelling uncertainty (DECC, 2012), as it may be influenced by social, economic, and cultural factors, as well as the age and physical status of the occupants. It is rare to find sources of data that may combine energy supplied to the dwelling with energy demand – physical attributes with occupant's behaviour, if simplified. A particularly useful source of data in this regard is the government's English Housing Survey (EHS). As an aside, there are Scottish, Welsh and Northern Irish national surveys of their own, but these are pared down versions of the English survey, which itself represents over 83% of the UK housing stock (Sousa et al., 2017). The EHS adopts a clustering method to select a statistically representative sample of more than fourteen thousand English homes. The data collected includes a household questionnaire and a physical survey of the building's attributes. Many housing stock energy models have used the EHS to develop their studies, and the paper from Sousa et al., (2017) looks to compare their reliability. Of the 27 tested in Sousa's paper, Building Research Establishment Domestic Energy Model (BREDEM) and Standard Assessment Procedure (SAP) are found to be the most robust, in part because they make standardised assumptions about energy *demand*, and focus on the efficiency of the building fabric, and its use of energy *supply* (Sousa et al., 2017). However, comparisons of the software models is a digression for context only, where policy and modelling the data here is the focus.

Even when eliminating the wide-ranging variables concerning occupant behaviour and energy demand, and instead focusing solely on building fabric, there are notable concerns about the use of EPC data when reporting national (or for that matter individual dwelling) energy efficient status. In a paper by Gledhill (Gledhill et al., 2016) a phenomenon of default rounding down where dwelling attribute data is unavailable or unobtainable in the RdSAP model is analysed, on a hypothetical basis. This, it is asserted, could have a significant impact on the SAP and EI scores for a single dwelling which, if extrapolated, could paint a more gloomy picture of the energy efficient status of a region, or a nation's housing stock than may actually be the case. Ahern and Norton (2020) investigated this effect and modelled the outcomes. They explain how, due to retrofitted improvements in thermal efficiency to much of the nation's existing housing stock (especially older housing stock), either by virtue of previous energy efficient schemes levied on energy companies (such as those discussed shortly) or by homeowner funded upgrades (such as replacement double glazing, heating systems etc) the default assumptions of RdSAP where information is not/cannot be collected by the DEA, are set at the levels which would have applied when the dwelling was originally built. These, Ahern argues, are unrealistic.

2.5.1 Top-down EPC analysis

EPC data is used for 'top down' (Kavgic et al., 2010) analysis (see Figure 20 in the next section), such as that collected within the English Housing Survey which feeds in to numerous statistical overviews, such as national projections for energy efficiency savings, the effects on GDP of retrofit schemes, the effect an increasing and ageing population may have on energy use in buildings, and the government's 'fuel poverty' statistics (DECC, Annual Fuel Poverty Statistics Report, 2015). This report looks at both trends and projections of fuel poverty based on RdSAP and BREDEM (RdSAP's parent method, available here: http://www.ncm-pcdb.org.uk/sap/podpage.jsp?id=6). On a smaller scale, the RdSAP question set is also transposed into many housing stock condition surveys so that energy performance data can be scrutinised for properties en-masse (DETR, 2000). In addition to practical applications, Zhang (Zhang et al., 2012), Banks (Banks, 2008), Swan (Swan et al., 2010), Oxera (Oxera et al., 2006), Kelly (Kelly et al., 2012), Fuerst (Fuerst et al., 2015) among many other academics undertake research and draw conclusions based on extrapolated RdSAP data, including that of the English Housing Survey (EHS). Aside from the key point here of increased use of RdSAP data at a 'top down' level, there is also a point to be made about from whom the data originally came. There is no prerequisite for surveyors working on the EHS to be qualified DEAs. This is to be discussed later in this chapter, and links strongly to the comments made by practising DEAs themselves in the following chapters. This may be seen as reason to question the quality of the EHS and other housing stock condition survey data, and this forms a theme that will run throughout this thesis from hereon.

2.5.2 Bottom-up EPC analysis

Although arguably better suited to the RdSAP model's design, the 'bottom up' (Kavgic et al., 2010; Baker, Smith and Swan, 2013) approaches are also widening and may also be criticised. These include EPC use for the government's Energy Company Obligation (ofgem, 2013) as noted above where until recently, carbon credits would be invoiced based wholly on the contents of each individual EPC in the form of carbon trading (Duxbury, 2013; ofgem, 2014). In Figure 20 below, Kavgic is measuring the effect on the economy of energy efficient improvements. A similar method of research could have been taken before the government's announcement of a voucher scheme for energy efficient improvements in August 2020 (BEIS, 2020). Kavgic records a bottom-up perspective and thus a measurable effect of individual retrofit technologies. Technologies A, B and C etc may be external wall insulation, loft insulation, and replacement heating systems, at, say, Victorian houses in the UK, and EPCs would typically be expected to model these effects. Moving up the scale toward the top, the next layers might record the economic impact of this, and the numbers of households who would benefit. While not exclusively sourced from EPC data, this too would be drawn from the likes of the English Housing Survey data set, noted above, where household numbers, dwelling ages, and dwelling energy efficiency (calculated with RdSAP), would all be recorded (DECC, 2017).

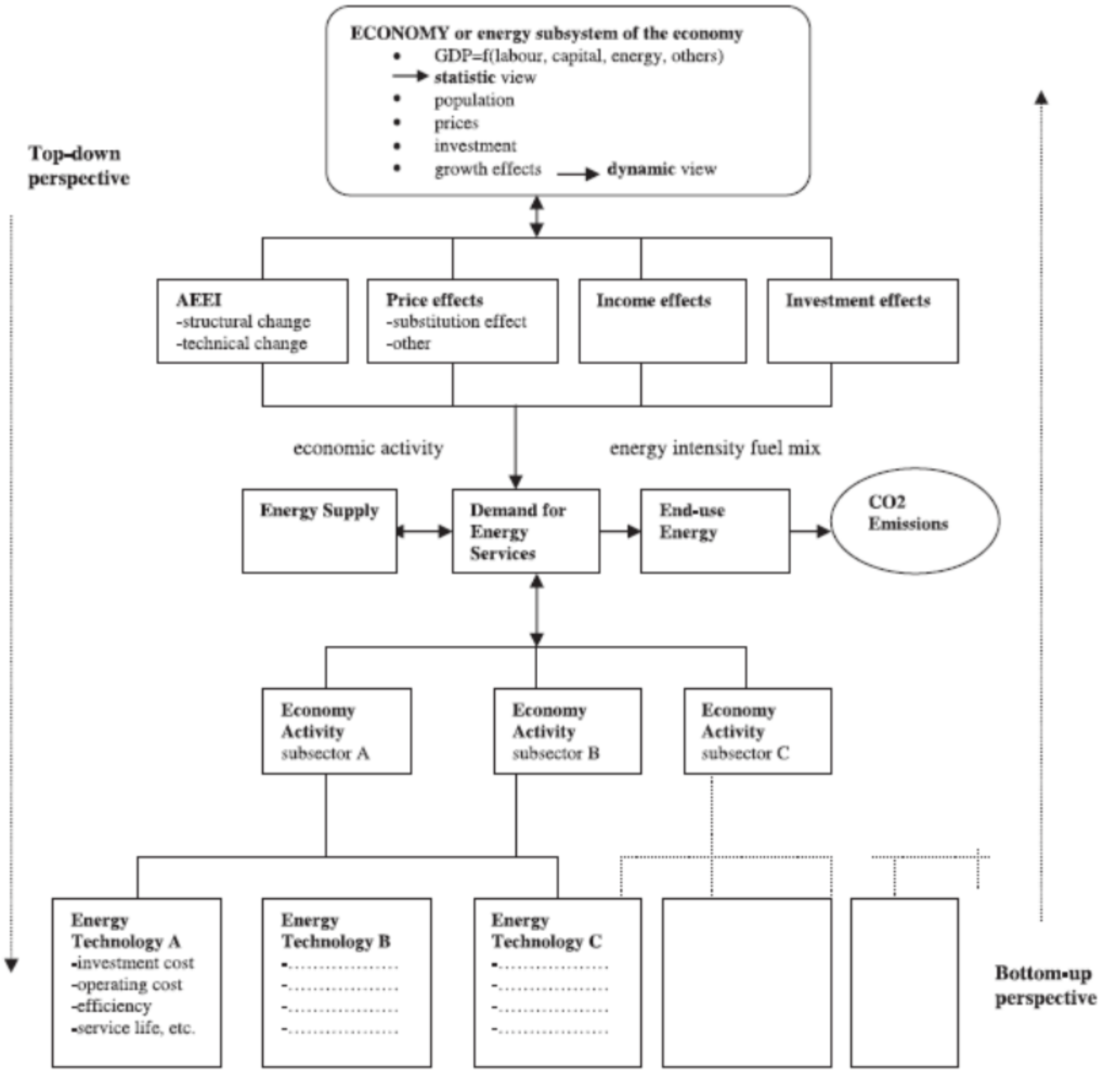


Figure 20: Top down and bottom up modelling approaches. Source: Kavgic, Mavrogianni et al., 2010

2.5.3 Adopting EPC improvements en-masse

Booth (Booth et al., 2012) studied the limitations of the EPC as a tool for en-masse reporting of, or retrofitting viability of housing stock, for example for use by a social housing landlord. They described housing stock energy data as being potentially unreliable for four key reasons: 1) surveyor variability (which is discussed in its own section later in this literature review), 2) heterogeneity of housing stock, 3) Parameter uncertainty, defined in two distinct categories by the author as the 'epistemic uncertainty', or the surveyor's view of the world, and the methodological parameters that RdSAP put in place to assess viability of insulation measures. Finally, Booth notes ignorance as the fourth reason for unreliability. Booth's model for addressing these uncertainties is described as the Stochastic Urban Scale Domestic Energy Model (SUSDEM), and the framework for this is presented in Figure 21 below. In similar manner to Palmer and Cooper, and Stone (DECC, 2013; Stone et al., 2014), discussed later in this chapter, Booth found key, or dominant parameters for uncertainty in modelled energy data for housing stocks, and uses a statistical, Bayesian method to calibrate the collected data in order to report on the likely margins of error. This approach is deemed successful by the author, but it is noted in the work that calibrating the data collected within an 'engineering based model' such as RdSAP could in theory lead to further ambiguity over how inaccuracies in the original data came about, and whether they should be modelled in this way, or investigated further. Also, the study was undertaken on a flat block, where all dwelling types have similar characteristics. There may be greater difficulty in 'smoothing out' results from more heterogenous dwelling types. Even if they are separated into 'archetypes' or broad dwelling types at the outset (ie houses, flats, bungalows etc), they are unlikely to share such similar characteristics as flats located in the same block, which may have been managed and maintained with the same materials, installed around the same time by the same landlord.

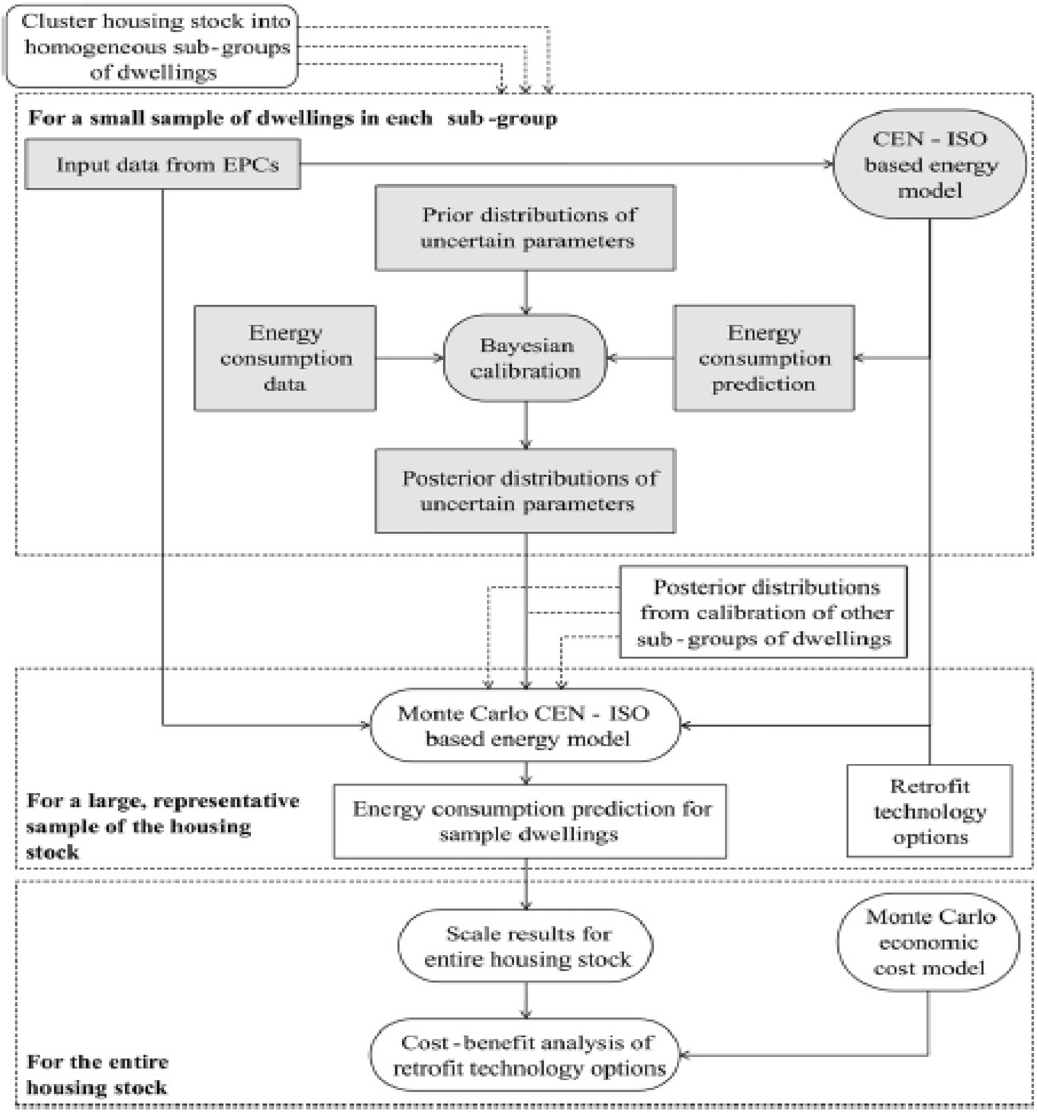


Figure 21: extract from Booth et al., 'Handling Uncertainty in Housing Stock Models' showing the structure the SUSDEM model and research process Source: Booth, Choudhary and Spiegelhalter, Building and Environment 48, pp 35 – 47, 2012

Fan (Fan and Xia, 2018) studies a similar topic, adopting a mathematical model to improve EPC data for the purpose of outlining effective retrofit options. Fan proposes two optimization models that would 'bolt on' to the EPC data collected on site for entry into RdSAP, as follows:

- Model 1 offers a straightforward (theoretically at least) calculation of the proposed retrofit measure (i.e., external wall insulation, heating system upgrade) which presents the overall saving, set against the estimated overall cost, and

- Model 2 elaborates on this, by offering greater flexibility, for example by treating different floors of the same building with different measures, something Model 1 is unable to do.

These models are applied to a case study building which yields, superficially at least, coherent results. However, Model 1 in particular may be criticised for not taking into account the heterogeneity of housing stock, and the complexities inherent in retrofitting it. For example, installing external wall insulation would be calculated at a flat rate per square metre in the model, but the cost to install external wall insulation to, say a typical circa 1930's constructed detached house with bay windows, arched lintels (over window and door reveals), and externally supported (hence externally protruding) chimney breasts may be considerably more complex, hence more costly, than installation at a typical circa 1900 constructed terrace house with only two elevations, flat (straight) lintels and no bay or chimney breast protrusions. Also, more succinctly, the calculations are only as accurate as the data that is put in to RdSAP, and this is central to the research focus.

2.5.4 Other uses of EPC data

The CERT and CESP schemes, and their transition into the Energy Company Obligation noted earlier in this chapter, as well as the Green Deal and the compilation of EHS data discussed above, mark an important broadening of the use of the EPC. In 2008 the provision of EPCs to householders constituted their sole function. This was their primary intended use, and the reason for which they were created and allocated the status of NCM (national calculation model) as noted earlier in this chapter. There was no further purpose outlined for them under the EPBD that instigated their widespread, mandatory use throughout the UK.

Whilst the Green Deal Finance Company is now defunct, Green Deals, at the time of writing, are at least technically still available, and EPCs produced for this purpose will have a direct impact upon the energy savings calculated, and thus the funding available and the availability of measures, which are ultimately governed by the Green Deal's 'Golden Rule' whereby by the insulation measure must be paid for in full within its lifecycle, at a repayment rate no greater than the energy savings made by installing the measure over the customer's pre-installation energy bill (Mallaburn, Eyre, 2014). Where this is not the case, the insulation measure will not be available under the Green Deal and would have to be directly funded by the householder, rendering the Green Deal obsolete in many instances, and potentially restricting its use by the fuel poor – those who one might argue may be most in need of what it has to offer. The Renewable Heat Incentive (ofgem, 2014) also relies upon the EPC for the calculation of grant contribution levels to householders. Also, and similarly, the government's 'Feed in Tariff' (FIT)(Ofgem, 2017) has within it a benchmark for approval of funding at the highest rate only for properties rated RdSAP Band D or above, and an EPC must be produced to establish this. This has the potential to lead to pressure upon DEAs to get properties 'over the line' to facilitate maximum possible grant funding. More recently, from April 2018 a minimum RdSAP score of Band E or higher has been put in place for properties in the private rented sector (gov.uk, 2018), which again could lead to pressure being brought to bear for any DEA producing EPCs for landlords or letting agents.

EPC data is relied upon by policy makers, analysts, researchers, energy efficiency installers, as well as householders and individual occupants to whose lives the data may directly impact, and as can be seen here, all of these are recent developments (since 2008) that were unlikely to have been foreseen when designing RdSAP for the production of EPCs. This is central to the focus of this research and therefore forms the primary focus of the interview questionnaire put to qualified DEAs, the results of which are discussed in Chapter 4.

2.6 THE PERCEPTION OF THE EPC IN THE UK

2.6.1 The perception of the EPC

The way the EPC is perceived, both by individual recipients, the wider public, and professionals and academics is important to this research, because it gauges a level of trust, which is increasingly important as the EPC's uses broaden. Faith in EPC outputs, and by association EPC processes and procedures is therefore essential: any variability shown in EPC results would impair that faith and must be addressed promptly if the data presented both to individuals, and that which is collated en masse is to be relied upon, moreover acted upon.

In the work of Watts (Watts et al., 2011) a postal survey was issued to individuals who had recently completed the purchase of their home in 2009. One respondent's feedback encapsulates a common theme identified in their analysis of the survey data, that the EPC presentation was too simplistic: 'the EPC added nothing to the other information available. It is obvious from looking at the house, for example, that there was no double glazing'. Kelly (Kelly et al., 2012) support this, asserting that the contents of the certificates are simplistic and not sufficiently tailored to the individual property.

The value of the EPC as its primary function of informing, or enlightening householders has been called into question by Watts (Watts et al., 2011) and Amecke (Amecke, 2012). Watts' survey of 347 householders in the Southampton area was conducted during 2008/09, soon after the EPC became a mandatory requirement on the 1st October 2008 (in England and Wales). Among the conclusions drawn, a consensus was noted around the lack of consumer interest in the certificate: not one respondent of the 347 selected energy efficiency as their highest priority when evaluating the purchase of their property. Amecke, based in Germany, undertook a similar study in 2011, involving 662 respondents from an original sample of 2056, who were contacted by email in July 2010, and invited to complete a web-based survey. The study, like Watts', evaluated the user's opinion of the EPC's effectiveness, particularly in respect to its impact on private purchasing decisions for existing dwellings in Germany. Like Watts', Amecke's study suggested the EPC played only a limited part in purchasing decisions, and in many cases was not viewed at all. Amecke attributed this to a small number of different reasons: a) purchasers may have understood the information but did not trust it, b) EPCs do not show the financial implications of energy efficiency well , and c) purchasers care significantly less about energy efficiency when they are purchasing a home than about location, price, space, for example. Watts' and Amecke's findings are in contrast with those of the Energy Saving Trust (EST, 2008) who claimed quite the opposite; that '78% of people in the UK consider it important to see the EPC rating prior to buying a property, and one third of people stated that the EPC rating would influence their choice of home'. Whether this may appear unlikely or not, this is an assertion made from a study undertaken prior to the mandatory introduction of EPCs, and responses from the same questions now may be quite different because of the rapidly increasing focus on the climate crisis over the last decade, the culture of saving energy this may be said to have brought about, and rising energy bills (Rosenow et al., 2018).

The extracts taken from both Watts and Amecke, as well as other studies that drew similar conclusions to theirs (Fuerst, 2016; Laine, 2011; Adjei et al., 2011) are worthy of note, as the contents of the EPC as well as its accuracy are questioned: these are issues that feed directly into this research. The studies aiming to correlate energy efficiency with the decision-making process feeding into buying a property are mounting up, and few recent studies are able to make a strong case for a correlation between the two.

2.6.2 EPC ratings and house prices

In addition to this, but with a subtly different shift in focus, there is also literature aimed at correlating house prices with energy efficient scores (Davis et al., 2014; Fuerst et al., 2015; Jensen et al., 2016). The study by Fuerst (Fuerst et al., 2015) looked into the correlation between EPC rating and house prices and concluded that there was a positive correlation between the two. While they confirm that location, size and dwelling type would be the first considerations of any prospective purchaser, they used a Hedonic Regression analysis to consider how energy efficient status may impact house price. They found that, notwithstanding a very heterogenous group of detached, rural dwellings, all house types in their study - which included analysis of 333,095 properties in total - correlated positively with market value and improved energy efficiency. Two potentially fundamental shortcomings may be directed at Fuerst's research, however. Firstly - and this is touched upon as a limitation in his work - is the strong likelihood that a dwelling with more energy efficient attributes will be in generally better condition than a similar property with an inferior energy efficient status. This may be seen as common sense. Heating systems, glazing, doors, for example, will have a marked impact on the overall condition of a property. Modern installations will reduce ongoing maintenance costs, and hence increase desirability for a prospective purchaser, irrespective of the improvement that will be seen in the energy efficient score. One could go a step further here and assert that a property with a more modern space heating system, windows and doors, may also have a more recently installed kitchen and bathroom, and other more modern fixtures and fittings. This is likely to be a more valuable property. Secondly, Fuerst notes that price increases are more marked in properties attributed with EPC bands A and B. These are likely to be modern properties, as it is challenging to retrofit an older building to such a high standard: Fuerst recognises this, but he does not consider the possibility that a proportion of these may be new properties. If so, this more marked rise in value commensurate with energy efficient status may in part be attributed to a 'new build premium' – a premium that is proven to exist among the purchasers of newly built properties (RICS, 2019). The study does not point to this as a potential limitation. Hedonic studies focusing on market values such as these contain only the variables that the author chooses to consider. Thus, by their nature, and by admission of this author, they may overlook some important variables, or attribute inadequate weight to variables that are considered. In this way, studies of this nature can be subjective, or even inaccurate. In truth though, it may be considered very challenging to separate the energy efficient status of a dwelling from all other variables, in order to appraise its impact on market values independently.

In the study by Watts (Watts et al., 2011) there are observations that contrast heavily with the EST report (EST, 2008) noted above. Watts found that, in respect of a prospective house purchaser's decision to proceed, 55% of respondents regarded the EPC's contents as having no influence in their decision at all, with 26% confirming it had 'not much influence'. 95% of respondents confirmed that the contents had 'no or not much influence on negotiating the sale price'. The EST study found '70% of people would consider renegotiating the price they pay for a property if they discovered it was highly energy inefficient. Clearly there are gaps between the two sets of findings, and it is possible that this can be attributed to some extent to the hypothetical nature of the EST study, while Watts had taken feedback from individuals who have recently completed a property purchase. The conflicting results may well warrant further investigation.

However, whether conflicting or not, tests of public perception are vital to the successful take-up of energy efficient improvements by the general property owning public. Public perception of the EPC is as important to its effectiveness as the accuracy of the information contained on the certificate, in the opinion of Banks (Banks, 2008). In his study, it was found that the majority of house sellers had a negative attitude towards EPCs. The common attitude was resigned acceptance, with a degree of distrust about the process that at the time had been another, newly enforced layer of red tape, with speculation that EPCs were just another stealth tax applied by the government. This, with the benefit of hindsight however may have been an opinion partly formed in light of the doomed Home Information Pack (DCLG, 2010) which received some bad press, and of which the EPC was part. Banks found that estate agents had a similar view however, speculating that the process was just a “big con” where they were left wondering what was gained from the scheme. Again though, this test of opinion was undertaken during the immediate aftermath of the Home Information Pack, and this may well have been a contributing factor to negative opinions. This type of attitude was widespread, and may have an overall detrimental effect on the public perception of EPCs, but over a decade on from this study, it is possible that perceptions have changed, maybe reinforced by the marked rise in energy prices that has come about in the UK in recent years. It is possible that poor public perception will create inertia against enthusiasm for installing measures recommended in the EPC, but recent tests of public perception have not been undertaken, and in light of rising energy prices, Home Information Packs now being a distant memory (ODPM, 2007), and an arguable increase in public perception of the need to save energy more than ever before, a test now may bring about some different results.

2.6.3 EPCs & the culture of domestic energy consumption

The EPC is uniquely well placed to drive a cultural change in domestic energy use, by providing the tools necessary - and bringing about some enthusiasm for - the installation of domestic insulation measures, and efficient heating systems. In order to achieve this, the EPC’s contents must be trustworthy and accurate, and tailored in the best possible way to drive both policy when scrutinised en masse, and actions by householders on an individual basis. Chahal (Chahal et al., 2012) discuss the potential for a cultural change to drive energy efficiency, and point to comments made by the Economic and Social Research Council (ESRC, 2009) regarding cultural changes relating to drink driving, smoking in confined spaces, and the wearing of seatbelts. Behavioural interventions using social norms have been successful in these areas, but Chahal et al., quite pertinently note that it is ‘hard to imagine inefficient homes being frowned upon in quite the same way as drink driving, for example’.

Reid (Reid, McKee and Crawford, 2015) discuss the culture of conspicuous consumption and stigma, inferring that high energy consumption may be linked with high status, and that low status, low-income households may be further stigmatised as poor by being targeted by energy efficient retrofit programmes. Hards (2013) puts forward a similar argument, that conspicuous energy consumption and energy conservation may be status enhancing and have the potential to generate stigma respectively, asserting that ‘energy practices are deeply contextual, shaped by inequality and power’. The philosophical underpinnings of Reid’s argument are drawn from Pierre Bourdieu, a European sociologist whose central thesis is ‘that one of the fundamental predicates of the human condition is the universal dependence on the judgement of others’ (Bourdieu, 1994). He asserts that perception is largely defined by individuals’ location in social space, which is itself largely determined by the structure and volume of the economic, cultural and social capital of the agent, and those within close proximity to the agent. This may be seen as a simple and robust approach at its most basic level, that for example the resident of an expensive house, with expensive artwork hanging on its walls infers wealth and status – arguably also knowledge, and that conversely the inexpensive, poorly maintained house with basic, simple furnishings would infer the opposite. Reid’s and Hards’ arguments may be seen as compelling, but they draw the conclusions that energy efficient retrofit programmes and energy efficiency carry with them a stigma. By their own admission there is limited evidence for this, and the evidence sourced by Reid is not entirely robust. While Swan (Swan et al., 2017) supports Reid’s and Hards’ theme that the focus of government policy is moving away from carbon emissions and toward fuel poverty, there is also evidence to the contrary. For example, the CERO (carbon emissions reduction obligation) sub-section of the government administrated Energy Company Obligation, is aimed at a property type and not means tested or geographically targeted. As noted earlier, the CERO is by some margin the larger of the three schemes that the Energy Company Obligation is divided into at present. Also, the roll out of smart metering, discussed elsewhere in this section, does not discriminate between householder or house type. Furthermore, the government’s Feed In Tariff, Renewable Heat Incentive and (albeit now essentially defunct) Green Deal are not limited to any particular group or type. Technology may often be perceived as the domain of the wealthy, and many energy saving measures are bound up in technology that may be seen to excite the knowledgeable, and only be available to higher earners - at least at the outset. Tesla’s ‘Powerwall’ (Tesla, 2020) may be seen as an example of this. Brown (Brown et al., 2014) indirectly supports this in a paper discussing social housing tenant reflections on energy efficient retrofit technology, where a theme encompassing a lack of engagement with the technology emerges. As with Chahal's point about seatbelts, a cultural shift may be seen to be occurring in respect to energy efficiency where, maybe, excessive and conspicuous consumption is not perceived so widely to be representative of success and status, and consequently Reid's comparatively recent, 2015 argument may already be less relevant. Reid references Telfer (Telfer, 1984) who makes interesting points about energy saving being perceived as 'doing without', and Hards infers some energy efficient technologies are 'trashy, or 'low class'. Clearly these are unhelpful in a cause to improve energy efficiency in the context of this research, and worthy of note, despite Telfer's observations being made some thirty or so years ago. One might hope that a cultural move away from this perception has occurred, and some of the more recent literature (Swan, 2017; Chahal, 2012) may support this. Reid's comparatively recently written paper may have been misguided in referencing material from so long ago in supporting an argument centred around the *culture* of energy efficiency. However, should these perceptions still remain, even if to a lesser extent, an improvement in the perception of the EPC and its contents may help to tackle this.

2.6.4 EPC improvement recommendations

An important contribution to the potential improvement of public perception of the EPC may be linked to the break-down of cost-effective improvements listed on the certificate. Research (Oxera, 2006) has shown that most residents have little or no knowledge about the characteristics of energy efficiency, including costs. For example, his study showed that only 8% of respondents were aware of accreditation schemes for existing domestic insulation installers and significantly overestimated both the time and cost of installations. This highlights the importance of providing an indication for the true costs and savings to a dwelling. This point is reinforced by Chahal (Chahal et al., 2012) who write that a lack of understanding of the cost, effectiveness and time taken to install measures all act as a barrier to installation. At present the costs published on an EPC may be considered vague (see Figure 22 below), and savings are not linked to any net present value or other forward-looking cost formula, so take no account of rising energy costs (Appendix S, BRE, 2014). This does not help the 92% of respondents in Oxera's paper who were unaware of the costs associated with installing measures, or the potential savings they may glean as a result. If the assessor who undertook the EPC had some knowledge of indicative costs him/herself and was in a position to marry these up with the outcomes presented on the EPC, that might be beneficial – but this lies beyond the assessor's training, where there is no inclusion in the training course for the prospective DEA to learn about the costs, procedures or timescales associated with installing energy efficient measures (Energy Trust, 2015; Elmhurst Energy, 2014). As an aside, this may be addressed by factoring in a simple multiplier to the SAP model for these estimates. For example, a wall surface area is calculated in SAP in order to measure heat loss, as is floor area/roof area for the same purpose (Appendix S, BRE, 2014). So a multiplier at, say, £20 per square metre for cavity wall insulation would arrive at a cost of £1,600 for a house with 80m2 of exposed wall – arguably typical for a 1950's ex Local Authority semi detached house at the time of writing (Insulation-info.co.uk, 2018). Having this figure on the certificate, with an anticipated installation period added, may be considered more helpful than the current range of £500 to £1,500, marked up in Figure 22 below, which may not be seen as 'indicative' at all (although a more accurate estimate would come with the caveat that local variations can occur – regional variations could in theory also be accommodated into the EPC, though other commercial variations may be challenging to cater for and customers should be advised to obtain multiple quotes from installers, as well as investigate any potential grant funding). In the interest of bounding the research however, no further recommendations need be made by the author on 'SAP fixes'.

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

Recommended measures	Indicative cost	Typical savings over 3 years	Available with Green Deal
1 Cavity wall insulation	£500 - £1,500	£ 411	✓
2 Floor Insulation	£800 - £1,200	£ 105	✓
3 Low energy lighting for all fixed outlets	£95	£ 102	

Figure 22: Extract from EPC showing indicative costs and typical savings of recommended measures. Source: W-Y-P Gledhill, 2012

2.6.5 The EPC's EI score, the occupancy assessment and smart metering

Another source leading to a potential lack of confidence in the EPC is its environmental impact score. As part of the (now essentially defunct) Green Deal (Rosenow and Eyre, 2016; Green Deal Orb, 2012), the RdSAP model discussed earlier in this chapter looked to ‘bolt on’ software that would process energy demand by interviewing occupants to understand their behaviour and add data from their energy bills, thus creating a system that would encapsulate the EPC’s comparatively sophisticated building fabric data with the otherwise standardised energy use of the occupants. This might be said to ‘catch all’ in relation to the EU’s 2010 demand to have member states adopt a system incorporating one or another approach at its core, as may be seen in Figure 23 below, where the EPC alone would sit toward the left side of the scale.

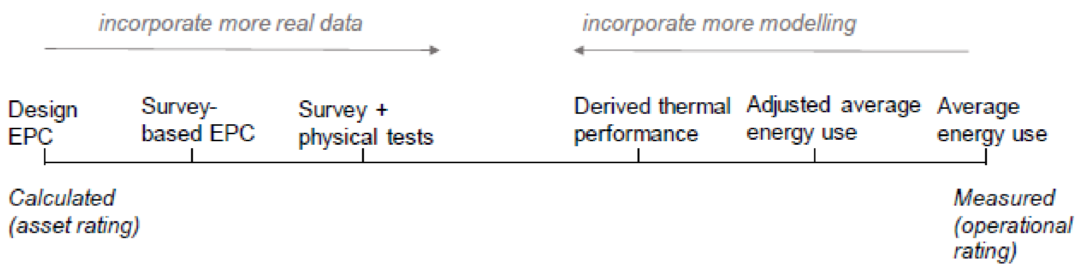


Figure 23. Scale showing current energy rating methods used by EU member states. Source: Crawley et al., 2019

Here, the EPC can be marked clearly as an asset rating, with survey data about the fabric of the building collected on site and entered into the RdSAP software model. Operational data relating to the actual use of the building by its occupants is not incorporated into the RdSAP model, intentionally so as to allow like for like comparisons between buildings based on ‘normative’ use (BRE Appendix S, 2012). The ‘Occupancy Assessment’ (Marchland et al., 2015; Green Deal Orb, 2012) created in order to facilitate the Green Deal programme looked to bolt on the occupant’s energy use to the RdSAP model, thus allowing the occupants of the building the opportunity to assess the likely benefit of energy improvement measures for them personally, and the impact their actions have on the environment, where standardised, normative fuel consumption would otherwise be defaulted by the RdSAP model. This process may be considered a time-consuming operation however, with not only the need to collect data for the EPC, but also to then interview the occupant, and collate their energy bills. More recent developments of technology – in particular smart metering, may be a more sophisticated route to obtaining a similar picture of a building.

The EPC's environmental impact, or 'EI' section (see Fig 11, Section 2.2.9) is calculated not only on normalised use, discussed earlier in this chapter (in order to make 'like for like' comparisons), but on RdSAP estimates of gas and electrical fuel costs, combined with the building fabric. These estimates of fuel costs were adjusted by the occupancy assessment under the Green Deal, but the laborious process is now essentially defunct and the RdSAP defaults are regarded by Lomas (Lomas et al., 2019; Lomas et al., 2019) as crude, and even after being heavily corrected (increased) in a 2016 revision of RdSAP (from 2010, by 71%), may still compare poorly as automated, normalised estimates to the collection of real data. Lomas' study encompassed 114 semi-detached, centrally heated houses in the English midlands, where a householder questionnaire was undertaken, an 'EPC+' was undertaken (EPC and home energy survey, involving an interview with householders), a smart meter was installed, temperature monitors were installed, and a weather station fitted, for a period of approximately 18 months. The study as a whole spanned from November 2012 to October 2018. This study measured gas and electricity demand by owner occupiers at homes where the personal circumstances of each occupant was well known and the property characteristics were broadly similar, so some normalisation of the data obtained could be undertaken. Energy demand across the respondents was found to vary greatly, being as high as 90:10% gas - electricity at one end of the scale, to 36:64% at the other. The highest consumers of energy were using 17 times more gas, and 13 times more electricity than the national average (as estimated by the English Housing Survey in 2016). The lowest users of gas and electricity fell below the national average, but not by the same margin. Lomas attributed this in part to the colder than average weather conditions during the measured period, but makes what may be seen as a reasonable argument in the context of his findings, that RdSAP defaulted estimates may be underrepresenting the likely actual demand of typical occupants, leading to potentially misleading EI ratings on the EPC, and misleading estimates of likely fuel costs. The 2016 revision of RdSAP fuel cost estimates are revised so markedly upwards that the strong likelihood is that EPCs produced before this time which and technically valid up until 2026 may be even more inaccurate. Lomas recommends his own system of standardisation or normalisation, producing a 'DOR', or 'dwelling operational rating', using the data collected in his study. The DORs he obtained through his study did not correlate with RdSAP's energy efficiency ratings at all well, indicating that in use, operational ratings may be seen as a separate reporting tool, arguably, according to Lomas, of greater use than RdSAP.

RdSAP may be seen instead, again according to Lomas, as an asset rating tool. Lomas' work may help lead to a more evidence-based approach to calculating the energy efficient status of a dwelling in use, although the quantity of data needed to produce these reliably across the country for all dwelling types and all heating systems, along with the data required to assess, then adjust fuel demand may present a challenge if consideration is given to rolling DORs out en-masse. Lomas discusses a 'reduced data' DOR, or 'RdDOR' based on the energy requirements of an occupied home at a flat 5 degrees centigrade – a standardised external temperature which would do away with the need to incorporate weather correction into the collected smart meter data. The figure of 5 degrees has been seen to reflect a standardised picture of overall annual weather conditions and has been used reliably in other studies by researchers focusing on domestic energy demand (Oreszczyn, 2006; Summerfield, 2007). Lomas found that the correlations between the 'full data' DOR and 'RdDOR' were strong, and this may help facilitate wider use of a DOR based function to guide prospective purchasers or renters in future. The RdDOR would be simple and less onerous to produce than an EPC, although it would present only very limited information about the fabric of the building, and so may not be considered useful in considering a programme of retrofitting for improved energy efficiency. In addition, like the EPC, any such RdDOR would come with the caveat that use of, for example, white goods (non-fixed electrical appliances are not estimated in the RdSAP calculator or in DOR/RdDOR for the obvious reason that they may not be used by the occupants), and varying charges from utility companies, along with Lomas' records which indicate widely ranging use of gas and electrical supplies by individual occupants, will mean any standardised figures given on a DOR or an EPC may be seen only as a guide.

Alzetto (Alzetto et al., 2018) researched the thermal loss of an 'equivalent building' (QUB). They did this by measuring the heat loss coefficient, or 'HLC' which, put simply, amounts to the superficially simple concept of thermal power loss attributed to the difference between the interior and exterior building temperatures. The process of HLC may be well understood (Bacher and Madsen, 2011; Mangematin et al., 2012; Bouchie et al., 2014; Farmer et al., 2017), but the methods of conducting it can be time consuming and may be challenging to place in a commercial setting to sit alongside, or within the EPC. The QUB method that Alzetto researched reduces this HLC calculation to potentially as little as a single night, though requires the building to be heated with a simple electric heater at the outset, ideally empty, in order to eliminate occupancy effects, and thermal loads. Despite reducing the time period required to produce what Alzetto determines to be a robust HLC calculation, these circumstances may still prove challenging in a commercial setting. Also, much like DOR and RdDOR discussed above, this test may not identify which building components are responsible for heat loss, and so like the DOR report, QUB may sit well alongside an asset rating such as the EPC which can, if accurate, point its user toward a programme of retrofit of specific building components which will help improve GHG emissions and comfort for the occupant. In addition to improved dwelling specific information, a combined EPC and QUB, or EPC and DOR rating may help provide more robust statistics at a macro level, so as to give an improved picture of housing stock, for use by policy makers, researchers, academics and other users of dwelling energy data.

Having given some background into what the EPC is, what it is used for, its model's perceived weaknesses, the policy that gives it context and its increasing importance and perception, this chapter will move on to look at the Domestic Energy Assessors (DEAs) who undertake EPCs. This progression may be seen as a 'drilling down' to the level which will inform the methodology and case study material in the following chapters, which underpins the hypothesis that triggered the research at the outset.

2.7 THE DOMESTIC ENERGY ASSESSOR, ACCREDTING BODIES AND AUDITING

2.7.1 The Domestic Energy Assessor

A Domestic Energy Assessor (DEA) is the accredited person in the UK that is approved to produce EPCs by the (current, at the time of writing) Ministry for Housing, Communities and Local Government (MHCLG). DEAs are qualified (and must also be accredited, a matter for discussion shortly in this section) for the production of EPCs: those which, as discussed earlier in this chapter, are specifically for use on existing buildings. As of November 2018, DEAs had produced 16,849,375 EPCs since their inception in 2008. These totals are numbers readily available from the government's 'EPC Register' (MHCLG, 2019). In brief, a DEA will carry out an appraisal of an existing dwelling's energy efficient attributes, and collect data relating (primarily) to the dwelling dimensions, construction type, and heating and hot water provisions of the property, entering these into an approved software model: the RdSAP, or Reduced Data Standard Assessment Procedure model which has been discussed earlier in this chapter. This produces the EPC which forms the central focus of this research.

DEA qualifications are defined in the National Occupational Standards (NOS) (DCLG, 2014). The NOS provide the specification of both the technical knowledge and the skills required to be a competent DEA. They include a requirement to understand the legal background to the role, to possess relevant interpersonal skills and make accurate judgments consistently, aided by the software, in order to work through the EPC process satisfactorily. The qualification itself is currently provided by three awarding bodies: the Awarding Body for the Built Environment (ABBE), City and Guilds, and the National Association of Estate Agents (NAEA). The qualification will require prospective DEAs to undergo a multiple-choice examination, and an assessment of not less than five EPCs (communities.gov.uk, 2012).

The domestic energy assessor qualification in the UK is described by Andaloro (Andaloro et al., 2010) as among the most comprehensive in Europe and given a maximum score of 3 out of 3 for both ‘values for uniformity’ and ‘values for excellence’ (see extract from their paper below in Figure 24). While this research does not extend to comparisons with the credentials of those qualified to inspect properties for the purpose of producing energy efficiency reports in other countries, it is worthy of note that in Andaloro’s paper, Luxembourg, Spain and Greece all have a prerequisite for energy assessors to be from a surveying, architectural or engineering background, and to be a member of a professional body. These individuals would then receive ‘top up’ training to qualify as energy assessors, according to Andaloro’s research. In the UK, no such prior experience is required, and this is pointed out in the interviews undertaken later in this study as one of a number of key issues that concern DEAs. Energy assessors qualify by undertaking a short (as little as one week ‘fast track’ Elmhurst Energy, 2014) training course, with no prior experience required. Once qualified to produce EPCs, these surveyors are assigned to an ‘Accrediting Body’ in order to obtain access to the RdSAP model which may be described as the calculator within which data is entered, and reports are produced. Accrediting bodies are required to undertake a desktop audit of 1% of the EPCs produced by energy assessors (Energy Saving Trust, 2015) and a CPD requirement

(20 hours annually) was introduced (in 2012). Beyond this, energy assessors are free to produce EPCs that, as mentioned earlier, may now in addition to the traditional function as a tool to inform the householder, be used as the invoice for, or underpin the system for carbon trading under the Energy Company Obligation (ECO, 2013) that can amount to thousands of pounds for any one property (Duxbury, 2013). Furthermore, the now largely defunct Green Deal funding and advice is dependent upon the accuracy of certificates and the technical understanding and advice that the assessor provides (Green Deal Orb, 2013). Also, SAP scores en-masse, as mentioned earlier, are scrutinised by academics and government alike, and feed into policy and research.

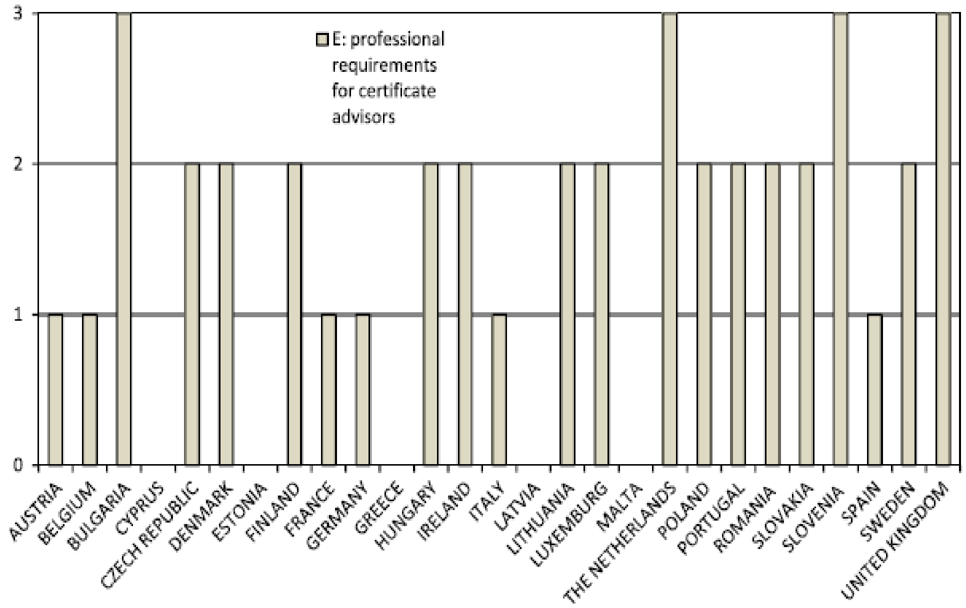


Figure 24: Extract from Andaloro et al. A high confidence rating is given to the UK energy assessment professional requirements in this paper. Source: Andaloro et al., 2010

Therefore, it might be reasonable to conclude that, sitting alongside the poor public perception of the value of the EPC as discussed earlier (Watts et al., 2011; Banks, 2008); Christensen et al., 2014), integral to any success in transforming this perception is the need to have well trained, well informed assessors. The current system of training and practice may not be considered sufficient for the increasing responsibility that lies with these assessors now. This is supported by the Zero Carbon Hub’s July 2013 report, ‘Closing the Gap’, where inadequate training of assessors is discussed in some detail earlier in this chapter. Chahal (Chahal et al., 2012) noted during a survey that a significant minority of tenants with newly installed energy efficient measures had not been provided with any follow-up support. This responsibility could sit well with the experienced energy assessor, and it may be considered good practice to provide incentive in the form of grant funding, carbon offset or similar for such follow-up advice, as misuse of heating appliances in particular is likely to lead to considerable additional unnecessary expenditure on fuel, alongside additional carbon emissions (Chahal et al., 2012). However primarily, simple skills such as measurement, observation and recording of data/data entry are all assumed within the training programme, which could possibly be considered an oversight given the analysis of surveyor variability that has been undertaken in the recent past (Kempton, 2002; Bonnefoy et al., 2007), as well as the material contained in the case study chapters of this research. Straub, who focuses upon the need for consistency, and outlines a prescribed approach to recording building condition which, it is hoped, will eliminate subjectivity (Straub, 2009).

2.7.2 Assessor competence

Imam (Imam, Coley and Walker, 2017) questioned the competence of the energy assessor within the context of the assessment process. In what may be regarded as a rare inquiry, Imam set aside the shortcomings of software models and building design to study instead the building energy modelers who use the software, in a study focused on their understanding of the building components and heating/insulation materials used in the building's construction. The paper made a case that building energy modellers were not 'model literate', which might infer that those (108) individuals tested - while not necessarily representative of all building energy modelers - were not able to prioritise the impact that variations in the performance of individual building elements might have on overall results: the paper ultimately concluded that because of this, there was insufficient depth to the knowledge of energy efficiency within buildings. There may be a case in Imam's paper to suggest that these modellers were instead not 'building literate', as opposed to model literate. This may be seen as semantics but may also be an important distinction. Their understanding of the software model may be reasonable, and indeed must be fair simply by virtue of their ability to use it. But there is limited clear direction in the paper regarding how well they understood the buildings their software was modelling. Indeed, Imam writes that their understanding of a building's constituent parts was such that their judgement when using the modelling software was of no greater value than making decisions about model inputs at random, in 25% of cases. However, the paper reports that building energy modelers educated to a higher level (though it does not say what field this education is in), or those with related professional backgrounds or considerable work-related experience (though again this may not be building related) fared no better than those with no formal professional qualifications and limited experience. Similar conclusions are drawn from the more wide ranging and comprehensive Zero Carbon Hub investigation, discussed earlier in this chapter, and much of this theme is borne out in both the interviews and the site based EPCs carried out as part of this research (within Chapters 4 and 5).

2.7.3 Accrediting bodies & auditing

A DEA must have undertaken training, passed a qualification, and become a member of an accrediting body recognised by the UK's Department for Communities and Local Government (DCLG). At its quickest, the qualification can be completed by a person with no previous experience of building assessment in five days at a cost of around £1,500 (Elmhurst Energy, 2016).

The UK Department of Communities and Local Government details the role of accrediting bodies (or 'schemes') and the role and responsibilities of the DEA (DCLG, 2011). In summary it states that:

'The (D)EA shall act in a professional manner, as defined by the National Occupational Standards for Domestic Energy Assessors (p.32) and 'An (D)EA shall not undertake an EPC if the nature of the property is such that the (D)EA lacks the competence or knowledge to produce an accurate EPC for that property.' (p. 32)

DEAs should also undertake CPD, such as updating themselves on new software models. Accrediting bodies have a minimum requirement to check at least one EPC per quarter year (where a minimum of one EPC has been produced) and 1 per cent of an individual member's EPCs over a year. Depending on the number of EPCs produced by a DEA, the checks should be randomly selected by the accrediting body, which also has the option of 'targeting' further checks on an individual DEA where results from random checks seem to highlight a problem. However, the checks are based on a desktop review of photographic evidence and site notes rather than a physical site visit, meaning that data could superficially appear to be correct, but in fact be incorrect. Gledhill (Gledhill et al., 2016) discusses this, and points to specific circumstances where the issue may become particularly problematic. So, in theory, it would be possible for the DEA to realise an error had been made but submit a pack of evidence that would give an impression to the auditor that the EPC was free from errors. This is touched upon in Chapter 4, where the material from interviews with practitioners is discussed. The wider phenomenon of human error is also touched upon in a publication by Kelly (Kelly et al., 2012), while work by the Zero Carbon Hub looked at variance of SAP as applied in new build housing and identified a wide variance between practitioners in terms of the difference between as built and as reported (Zero Carbon Hub, 2013). Given that full SAP has more inputs and may be considered a more complex model to use, consequently their assessors are trained to a higher standard (or at least more hours are required to acquire the qualification – 200 according to Elmhurst (Elmhurst, 2016)), this could imply that where variability is found, and proven by the literature from the Zero Carbon Hub, there may be a greater propensity for variability in RdSAP EPC outputs, because assessors undergo a less rigorous training programme. This, despite RdSAP created EPCs being used for by far the great majority of dwellings (secondhand dwellings, as opposed to SAP's use for new build dwellings – newly built housing stock accounts for approximately 1% of the total UK residential stock per annum (DCLG, 2018)). The extent of variability itself is an assertion which is challenging to underpin with evidence however, because there is limited literature with variability as its focus. This research is given as a contribution to knowledge in this respect.

2.7.4 Improving the EPC process

The system for auditing EPCs has remained largely the same since the EPC's inception, despite its broadening uses. This may be partly attributed to the fact that the Accrediting Bodies who audit EPCs have no direct interest in the EPC's contents. They are not consumers or suppliers, relying upon the service DEAs provide, nor are they driven by targets in relation to accurate EPCs by their members. It may be interesting to note whether any improvement in the quality of EPCs came about if they were. In addition, because most DEAs are self employed (Elmhurst Energy, 2014) it appears DEAs may fall largely outside of the types of systems and procedures that could help to improve standards, such as TQM (Total Quality Management) or ISO (International Organisation for Standardisation) systems. The issue of improving standards, or a lack thereof may therefore to an extent be identified as one of responsibility. Tsang (Tsang and Antony, 2001) identified supplier partnership/management as being at the bottom of the list of eleven ‘TQM critical success factors’ during their study of service industry standards in the UK. DEAs may often play the part of supplier in an organisation’s setup, for instance in the provision of EPCs that will ultimately calculate the carbon savings for energy efficient retrofit measures, in placing property for sale or rent through an estate agency, or as part of a housing stock condition survey commission for a social housing landlord. Even as part of the English Housing Survey (EHS), all the contributing surveyors are self-employed: they ‘supply’ services on a piece-work basis.

It may also be interesting to posit the argument that while a TQM, or ISO system may help to improve the activities of employed, or even self-employed service providing DEAs, the primary function of such a quality management system may not usually be seen as a technical one. These systems may instead focus upon timescales, safe working practices, delivery systems/software, customer experience etc. (Sun, 2000), over the actual contents of the report, which may be seen as a technical matter, to be handed over to the Accrediting Bodies for performance management. This may be seen to leave a gap for DEA’s services, so far as quality management is concerned, and the case study material in this research may indicate that a review of the system for recruiting DEA’s services, and monitoring and auditing their work may be beneficial, as a TQM or ISO type system, focused on the technical contents of the EPC may well be a suitable one for improving standards.

2.8 DEA VARIABILITY & EPCS

2.8.1 Keeping pace with the expanding uses of EPC data

The increasing responsibility that is placed on the DEA to produce accurate reports is a clear theme that has emerged in this literature review, and this focus will continue throughout the research. The SAP model is now the tool of choice for the ‘bottom up’ and ‘top down’ approaches to housing stock modelling (Kavgic et al., 2010). The bottom-up approach may be considered a more micro-focused, dwelling specific approach to the assessment of energy efficiency housing stock modelling, such as that carried out by Hardy (Hardy and Glew, 2019), whereas the ‘top down’ approach may incorporate the use of macro economic factors and extrapolation of other higher-level data (Swan and Ugursal, 2008; Hong et al., 2009; Straub, 2009), though ultimately all are centred around use of the RdSAP model at their core.

Where under the European Performance of Buildings Directive (EPBD, 2006) the primary aim of the EPC may be described essentially as a tool to inform the householder and increase awareness of energy efficiency at individual level, the EPC is now used, among other things, to analyse housing stock on a scale that may consist of many thousands, tens of thousands of properties, or even at regional or national level. The data may also be used to monitor improvements or extrapolate data relating to carbon emissions; it may be used to analyse the costs of fuel to householders (for example in data relating to fuel poverty), or comfort levels (for example in relation to health/hospital admissions), or to feed into the estimation of costs for the installation of energy efficiency improvements.

This upscaling from information relating to a single householder, on a single dwelling level has occurred gradually since the mandatory inception of the EPC in 2008. For this, consideration of the decision of assessors as a group may be worthy of note, more specifically, the margin of error that may creep into data when collected en-masse and then extrapolated up. Since the use of EPCs for this purpose is a comparatively recent concept, there is little available material on this, and this may be considered an area for which further research would be beneficial. That is because when looking at that literature that may be considered linked and relevant, the results are pertinent.

2.8.2 Surveyor variability and EPCs

Kempton noted that surveyor variability is not necessarily to be construed as error, but as difference of professional opinion between individuals (Kempton et al., 2000). Scope for variability may therefore take the form of a difference of opinion where, for example, a surveyor a) might elect to repair a window to extend what remains of its life before replacing it, but surveyor b) chooses straightforward replacement of the window immediately. Both approaches, Kempton argues, are justifiable, but each would have a very different impact on a landlord’s maintenance plan if the financial consequences of each decision are extrapolated out to reflect many thousands of properties. Ultimately, a degree of variability of this nature may ‘come out in the wash’, as surveyors with different opinions - so long as they are organised carefully (primarily mixed, geographically) throughout the project - would cancel each other out to form a mean, or average overall approach with roughly equal numbers of most possible choices. Straub, (Straub, 2009) concluded that with good guidance and ‘experienced eyes’, along with a careful system of benchmarking along the lines of that proposed in his paper ‘Dutch Standard for Condition Assessment of Buildings’, consistently reliable information can be obtained. Kempton is concerned though, and argues that, in relation to large scale housing stock condition survey reporting, ‘any variation in surveyor performance can significantly impact on the accuracy and, therefore, the effectiveness of these decisions’ (Kempton et al., 2001). Use of the word ‘significant’ may be considered strong, but there is robust evidence within the paper to support the theory that widely varying conclusions can be drawn by surveyors looking at the same element, at the same time. Similar evidence for variability in valuation surveying is offered by the RICS (RICS, 1996), where a study found wide ranging valuation figures from different surveyors for the same commercial properties, undertaken during the same period.

What is arguably of greater concern is the concept of surveyor ‘drift’ (Kempton et al., 2000), where interpretation of survey information is increasingly more, or less strongly recorded as a group, possibly as a result of external social or political conditions. By its definition, it is unlikely there would be any effective averaging out of such surveying to form a more reflective ‘mean’, and as such this drift would give spurious results that could prove costly to the end user. The case study data presented as part of this study was undertaken in insufficient numbers (both in terms of property types, and EPCs undertaken) to be able to give any empirical evidence of this.

The key driver behind the creation of RdSAP (from SAP) was to reduce the amount of data, the cost and the time required to produce an EPC (DCLG, 2013). This may be considered a reasonable intent, so that mass production of certificates can become a reality, and the RdSAP generated EPC is arguably the most advanced instrument in the UK of its type; a statement reinforced by the government’s support of the model in 2008 over other models, such as NHER (National Home Energy Rating). Overall, while not empirically tested in this research, it may be considered reasonable to assert that production of an EPC using RdSAP is not as complex or as subjective a task as surveying buildings with a view to assessing their condition. Kempton takes apart the decision-making process (Kempton et al., 2000) and divides it into four parts: Observation, Diagnosis, Prognosis and Treatment. With each stage comes an increasing level of subjectivity, and with that subjectivity a correspondingly increasing level of variability. In RdSAP, the model is designed to cut most of this subjectivity out. Broadly speaking, the level of 'Observation' is as far as the energy assessor needs to progress in order to collect and record data for the EPC. The assumptions that might be considered most subjective in the EPC, and possibly therefore the equivalent of Kempton's 'Diagnosis', 'Prognosis' and 'Treatment' (such as the occupant's use of heating, lighting and appliances and the measures one might apply to the building to help reduce energy use) are made by the model, and not by the assessor (BRE, Appendix S, 2012). So, it should follow that the variability noted in Kempton's study should not be so pronounced for the DEA using RdSAP, as software rather than an individual is making the decisions. However, there is an argument that there is still similar scope for these assumptions to layer up with inaccuracies, if the simple task of observation is not completed correctly. English Housing Survey benchmarking sessions are noted by Kempton. They may have included simple tasks contrasting different surveyor's measurements, recorded for the purpose of training and feedback, and it would be interesting to analyse the spread of these, aside from those, more subjective conundrums noted in Kempton's research, such as the extent of disrepair, or of dampness. For every simple measurement incorrectly entered into RdSAP, a number of assumptions are automated on the surveyor's behalf by the model, which in turn leads to an amplification of the erroneous data entered initially. This may potentially lead to similar discrepancies of variation, or worse still of 'automated bias', as the model software assumes a 'worse case' scenario in more instances than vice versa (BRE, Appendix S, 2012). Gledhill's hypothetical study (Gledhill et al., 2016) and the interview material and site-based study contained in Chapters 4 and 5 may be seen as compelling, and do - albeit within the constraints of the relatively small numbers undertaken - appear to support this phenomenon of 'automated bias'.

Ahern (Ahern and Norton, 2020) investigated the effect of RdSAP default data on dwellings in Ireland where energy efficient improvements are recommended. They support the findings of Gledhill with a more robust study and explain how the EPC overstates the benefits attributable to improvements, and describe this as a ‘prebound effect’. This is noted earlier in this chapter, but not in quite the same context: the default assumptions are set at levels which would have applied when the dwelling was originally built. These, Ahern argues, are unrealistically low and would contribute to the phenomenon of automated bias noted above, primarily because most dwellings - especially older dwellings - have been improved since construction, and this is not accounted for in RdSAP’s defaults (Ahern and Norton, 2020).

2.8.3 Research into EPC variability

While Kempton’s research into surveyor variation during housing stock condition surveys is compelling in this context, so are the findings of Ahern and Norton (2020) and Hardy and Glew (2019) who respectively note shortcomings in the RdSAP model and variation of EPCs following large scale, high level analysis. There are however marked differences between Kempton’s research in particular, and the research focus here. This section analyses the literature most closely associated with the study focus, where EPC variation itself forms the research subject.

2.8.3.1 Small scale EPC research

Jenkins (Jenkins, Simpson and Peacock, 2017) undertook a study whose scope encompassed four EPCs on each of 29 properties under the guise of a ‘mystery shopper’ exercise as part of the now essentially defunct Green Deal. The study data was commissioned by central government, initially for the purpose of understanding the customer’s experience of booking and having a Green Deal assessment (DECC, 2014), but the data lent itself well to Jenkins’ aim of identifying variation in the conduct of the assessments, to identify possible causes of variation, and to examine the implications of this. His results show variations in outcomes from one assessor to another. In Jenkins’ study, only limited data from each assessor’s EPC was made available for scrutiny (the EPC’s ‘xml data’ – the data set containing all inputs was not available). This may be seen to limit the depth of the study, as the EPC report itself (see Appendix A) displays only limited data.

With only four EPCs per property, there is limited scope to draw conclusions about variability, but even with small numbers (both of EPCs at the same property, and the total number of properties) it may be reasonable to agree with Jenkins' assertion that variability, which was found in each of the 29 sample properties, and pronounced in some cases, is unlikely to be confined to the sample. In addition to the four EPCs at each of the 29 properties, the original DECC study also undertook a control EPC at each property, given by the same company, C A Design Services. While reference is made to the control throughout the paper, and variation recorded against it, this control may not necessarily be seen as wholly robust. It is challenging to provide an entirely robust benchmark, or control, because there is always scope for error or variation in any DEA's work. This has to be - and is - recorded as a limitation, both here and in Jenkins' paper. The extent to which this limits the study's robustness may possibly have been mitigated by carrying out two additional measures. Firstly, the control EPCs at all 29 properties could have been undertaken by the same DEA, rather than simply by the same company, who may have numerous different staff, with varying levels of skills and expertise. Surveyor variability is a recognised phenomenon, and is noted by Kempton (Kempton and Nicol, 2001), and discussed elsewhere in this chapter. Using the same surveyor, while potentially giving rise to seeing the same variation or mistakes recur, would at least ensure a *consistent* control across all 29 properties. Better still however, and secondly, it may have been prudent to add an additional layer of robustness to the control by having it audited by an Accrediting Body. This system of auditing is discussed earlier in this chapter, and in the interests of avoiding repetition, is not explained again here. The system of auditing does however, by definition, add credence to the level of accuracy of a control. In the study here, unlike that of Jenkins, the control EPC is undertaken by the same DEA: the researcher, and each have been Audited by an Accrediting Body. The feedback from these audits can be seen in Appendices I and L.

As an aside to this section, Jenkins also questions the case for broadening the use of EPCs – a subject covered earlier in this literature review under its own heading. He asserts, for example, that we may wish to question the EPC's mooted suitability for linking back to council tax or stamp duty, or for gauging whether a property should be let – the latter of which is now embodied in policy in the form of 'minimum energy efficiency standards' (MEES) (BEIS, 2018).

Jenkins' paper points out that there is limited independent empirical data on the quality and consistency of EPCs, and notes that their own, relatively small sample warrants the need for further investigation on a larger scale. The next chapters of this research may be said to begin to address this.

2.8.3.2 Large scale EPC research

A unique case study which may be seen as fulfilling the element of scale that Jenkins notes as a shortcoming in his own work, is that undertaken by Hardy (Hardy and Glew, 2019), who use EPC data compiled by MHCLG into quarterly statistics (MHCLG, 2019) to compare and contrast historic and current EPCs held under the same address. This is a unique study, which to varying degrees was able to make use of all England and Wales EPC data: some fifteen million EPCs in total, at the time. Their research points to erroneous data in at least 27% of all EPCs where more than one EPC has been produced at the same property for any reason (up to 2016 when the study began). In Hardy's study, greatest variation was found among flats and maisonettes, which fall outside of the case study scope in this research. However, while scrutiny of such large numbers of EPCs can allow for comparions of all property types, and yield interesting geographical nuances in EPC data between one UK borough and another, the results may be seen as hampered in some other respects. Specifically, a lack of access to the DEA's direct inputs (the 'xml' data), and a need in its place, to apply algorithms and assumptions to headline EPC data in order to establish what may or may not constitute an error, may be regarded as a limitation. This brings about the possibility, for example, that a property which has been heavily refurbished between EPCs may be highlighted as containing errors due to its change in characteristics. Assuming variation is successfully identified, this approach would leave some important questions unanswered. For example, use of the EPC Register for EPC data will not allow the researcher to check whether the heating system is inputted correctly (the EPC will report the overarching heating type, but not specifically what system is fitted), whether a 'heat loss perimeter' is recorded correctly (the area of wall exposed to the elements, as opposed to that attached to another property), or whether internal dimensions are recorded accurately (the EPC reports only a total floor area, without recording the dimension of individual floors, extensions, or ceiling heights, the latter of which can be an important parameter for RdSAP in order to calculate the volume of space to be heated). There is also no control EPC using this approach, so while some conclusions may be drawn about the existence of variability, the extent of any departure from ‘correct’ cannot be ascertained.

While by no means as large as Hardy’s study, Tronchin (Tronchin and Fabbri, 2012) balances large scale with site data, in a study of 162 EPCs, all performed at the same detached single storey dwelling in an Italian town. The opportunity to conduct a case study arose as part of a vocational training exercise on new energy software (which was not RdSAP), not previously used (for any formally recognised function) in Italy. Notwithstanding the software itself, which was new to all participants and by the author’s own admission may have brought about the potential for erroneous data to have been inputted, the participants themselves were described by Tronchin as experienced experts from surveying, architectural, engineering or specific energy related (i.e. thermo technical) backgrounds. The test property was basic; a single storey rectangular building with kitchen, reception room, three bedrooms and two bathrooms. The building’s floor plan can be seen in Figure 25 below.

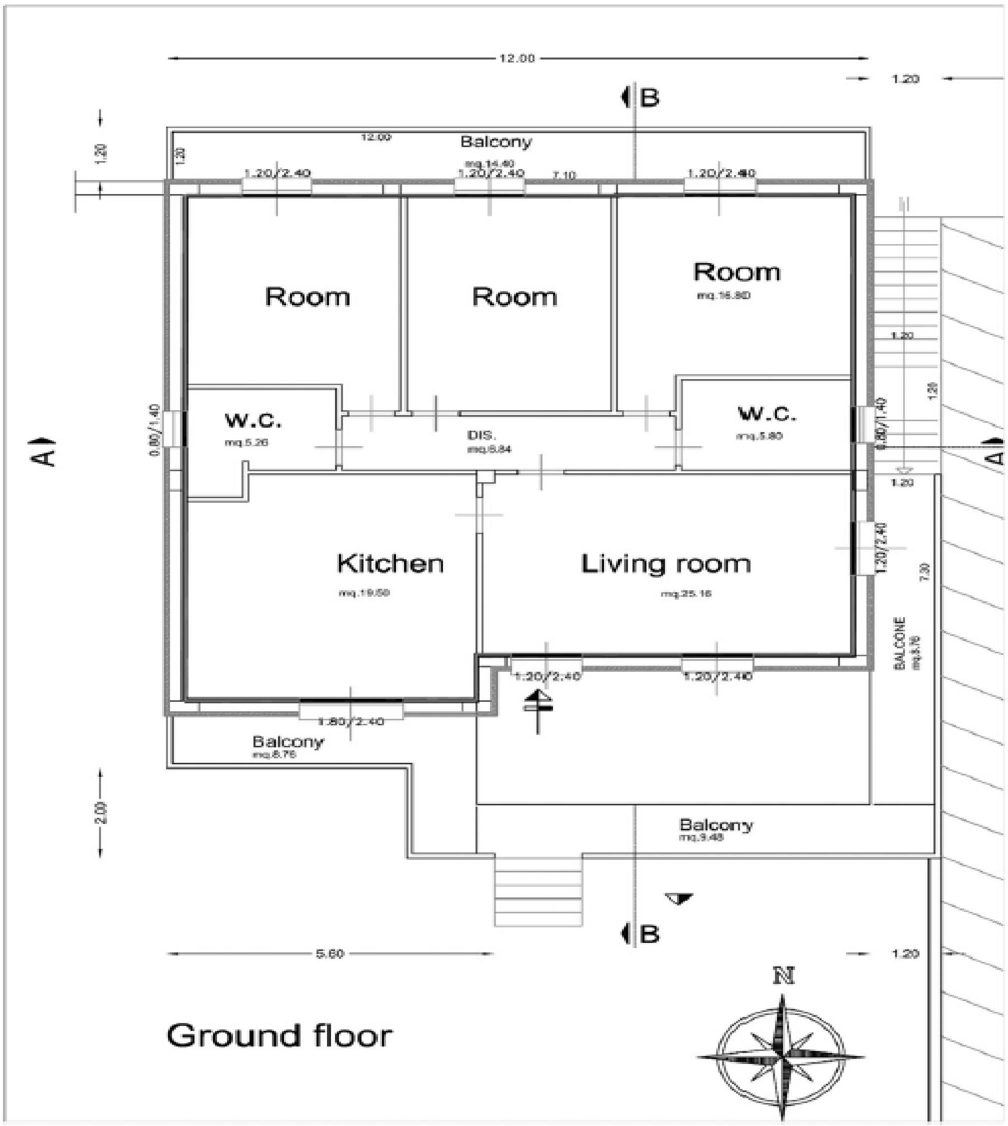


Figure 25. Floor plan of the Italian test property used by Tronchin et. al. for analysis of 162 EPCs. Source: Tronchin, L, Fabbri, K. Energy Policy 48, pp 176 – 184, 2012

Tronchin found over 70% of the 162 participants correctly scored the property with an energy rating of Band D. Of the remainder, 14.2% allocated the property a Band C, 9.26% allocated the property a Band E, 3.7% a Band B, and 0.62% gave the dwelling a Band A rating. These results are presented in Figure 26 below.

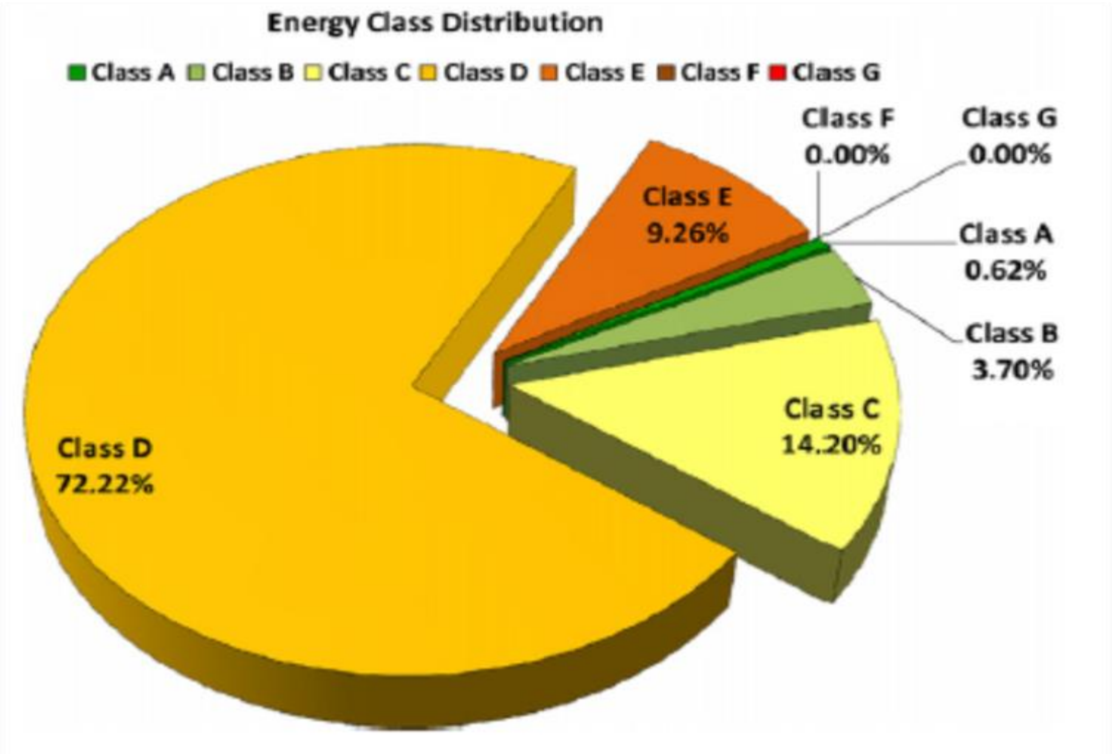


Figure 26. Chart showing spread of energy ratings recorded at the single Italian test property used by Tronchin et. al. for analysis of 162 EPCs. Source: Tronchin, L, Fabbri, K. Energy Policy 48 (2012) pp 176 - 184

The results bear some similarities to the spread obtained in this research study, but the interview component of this research looks in some depth at why the erroneous results came about. Tronchin's research does not really address this, and simply attributes the erroneous data (Bands A, B, C and E) to 'incorrect computer and software use, where input data was not properly understood', without qualification for the statement. Tronchin moves on to look instead at how these results convert to energy costs, and discusses the ramifications of this, so there is some departure in the study aim and scope. Also, the test property used for Tronchin's research may be considered basic, and with only one property used, the spread of dwelling attributes is limited. The research here acknowledges Tronchins approach but takes a different direction, partly in cognisance of the limitations of this study following the reading and digesting of its contents, but also so it may complement, rather than be seen to duplicate its results. This is discussed in more detail in the methodology chapter (Chapter 3) and the case studies themselves are recorded in Chapters 4 and 5. Finally, of note in Tronchin's paper is the limited discussion regarding the study environment and how this may impact upon Tronchin's results, and in particular on the existence of a control within Tronchin's study. Mention is made of Band D being the 'correct result', and the data would infer this, but a control, or ratification of the building's true value is not underpinned empirically, or even discussed. Unlike Tronchin's, this research discusses the procedure undergone to obtain a valid control, which included audit by the researcher's Accrediting Body, and discussion of the limitations relating to a control, even after this process. The research may be seen as more robust when some time has been invested in formulating a control, or benchmark by which other EPCs can be measured.

2.8.3.3 Dwelling components and EPC variation

Studies by Stone (Stone et al., 2014), and Palmer and Cooper (DECC, 2013) focused on those dwelling components which had the largest contribution to the observed variance of energy rating, based on the RdSAP section of the English Housing Survey data sets from 2009. Stone's study focused on gas centrally heated houses only, excluding flats and maisonettes. A ground floor and a roof were needed to qualify for inclusion in the study. Both Palmer and Stone looked at existing housing stock only, which is consistent with the study scope here. Both Palmer and Stone found the first three dwelling attributes with the greatest potential impact on an EPC's results were:

- dwelling geometry,
- heating system efficiency, and
- external wall U-value (the assumed thermal efficiency of walls as a standalone component).

These three components alone are shown by Stone to account for over 75% of the variance in SAP rating and Environmental Impact (EI) rating. This is mentioned here in the context of Jenkins' study (noted earlier in this section) where only the EPC itself was available for scrutiny, and not the xml data – the EPC's data inputs, or data set. This limits the depth of scrutiny available to Jenkins for his study. On the EPC report itself, dwelling geometry is summarised only as a total floor area. Dwelling geometry was marked as the most important variable by Stone et al., and consists not only of floor area, but also of ceiling height, and exposed wall perimeter. This means that the Jenkins' study was unable to attribute an area per floor, but only a total, and the data had no record of ceiling heights, or the proportion of wall that would be exposed to the open air, as set against that which was sheltered, or attached to other properties. The RdSAP model (Appendix S, BRE, 2014) understandably attributes a greater level of heat loss to exposed walls, than to sheltered, or unexposed walls, and calculates the volume of space that the dwelling's heating system must heat. Clearly then, neither can be scrutinised with the available information in Jenkins' paper.

Leading on from this, the heating system is marked by Stone to be the second most important variable in RdSAP. Information relating to this is also limited when viewing the EPC itself, and not the data that was logged to produce it. On page 2 of the EPC (see Appendix A) the heating system is marked on a scale of five stars: one being inefficient, five being the most efficient. This may be regarded as a fairly blunt instrument for the recording of heating system efficiency. For example, to achieve only one star, a primary system such as an open fire may be recorded. To achieve all five stars, a gas fired central heating system might be recorded. Other systems, such as electric storage heaters may be recorded in the middle of the scale (Stone et al., 2014). As an aside to the literature here, but relevant to this part of the discussion, all twenty EPCs scrutinised as part of the site-based case study in Chapter 5 were displayed on the EPC itself with five stars, because they had gas fired central heating systems (see Appendices H and K), but the underlying data still varied, and was seen to have an impact on the EPC's SAP scores (see Chapter 5). So, allocating the particular building component with five stars does not necessarily mean the EPC is accurate, and there is more discussion about the impact of this in Chapter 5. The point here is that this would not have been picked up in the study by Jenkins, where only the number of stars on Page 2 of the EPC were visible.

Finally, the third of the three variables noted by Stone was that of external wall 'U' Values (the thermal value of the wall)(Appendix S, BRE, 2012). In RdSAP, the thermal value, or U Value of walls is defaulted to a standard entry, based on two sets of inputted data: the dwelling age, and the wall type ((Appendix S (Rev. 19-11-2017), p19, BRE, 2012)). Neither of these inputs were available from the DEA data in the Jenkins study (although customer feedback relating to their estimate of when the property was built was available). This data is regarded as important by Stone and Palmer, and was scrutinised carefully as part of this study. The results are analysed in Chapter 5.

2.9 SUMMARY

The aim of this chapter has been to introduce the energy performance certificate, explain and critically analyse how it works, with supporting literature, discuss the policy context that motivates its broadening use, and analyse existing literature that critiques the EPC model, and where available, the literature which combines the model with its user to look at the EPC process.

The high-level context may be divided into three key functions. First, the EPC underpins official publications that purport to set out the current energy efficient status of housing stock. Secondly, these publications are used by academics and professionals alike to analyse progress and make recommendations for the future. Based on this analysis, targets are set by government and stakeholders to improve the energy efficiency of housing stock. Thirdly, we measure progress against these targets by using EPC data. In addition to this, there are micro-level functions underpinned by and justified with use of EPCs. These include the government-initiated schemes set out above, such as the ECO and the Green Deal, the Feed in Tariff and the Renewable Heat Incentive. On a dwelling specific basis also, MEES (Minimum Energy Efficiency Standards) legislation came into force during April 2018. This legislation aims to ensure that landlords of privately rented domestic property in England and Wales achieves an EPC rating of at least Band E, before granting a tenancy to new or existing tenants. As of April 2020 the requirement was extended not just to include tenancy renewals, but to encompass all private tenants in England and Wales, and further reviews with a move towards higher bands are mooted, though not at the time of writing set in legislation. Clearly then, the implications of inaccurate EPCs against this backdrop are significant, and as the EPC becomes more entrenched in policy at both macro and micro levels, there is a need to ensure it is a robust method to measure a dwelling's energy efficient status.

Continuing with the summary of this chapter, the figure below presents a simplified breakdown of the high level, social, and technical themes uncovered in the literature, and links these with the study aim. In doing so, the figure identifies themes that will require further research if EPC variability is to be better understood.

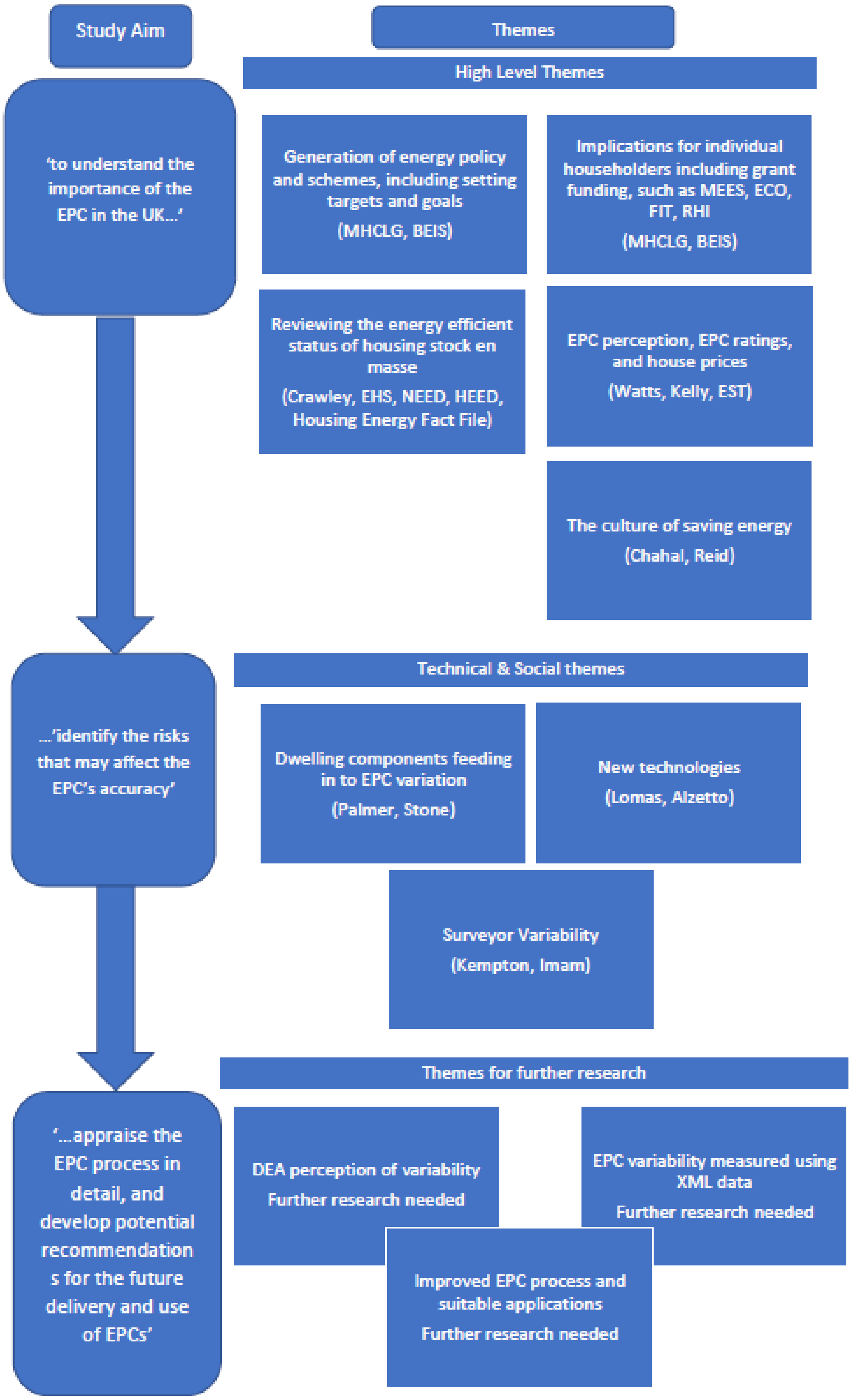


Figure 27. Chart showing themes identified in the literature, and areas that will require further research if EPC variability is to be better understood.

This literature review has discussed research closely linked to the study underway here, and identified gaps in existing knowledge that will benefit from being filled, if the existence of EPC variation is to be understood more fully, and EPCs are to be more accurate, or more carefully used in cognisance of their shortcomings in future. The research will now proceed to embark on the case study research, by first looking at methodological approaches that may be considered suitable and justifying the selection of one particular approach before proceeding to look at the case studies themselves within the selected methodological framework in order to identify as effectively as possible within this remit, the sources of variability and their extent.

CHAPTER 3, STUDY METHODOLGY: DEA INTERVIEWS AND SITE BASED EPCs

3.1 INTRODUCTION

This chapter looks to set in place a methodology that will identify the existence or otherwise of EPC variability. At the outset it may be appropriate to revisit the aim and objectives of the study, to provide a clear link between this and the process involved in identifying - and the ultimate selection of - a methodological framework that fits with the research proposal. The study aim is:

'to understand the importance of the energy performance certificate (EPC) in the UK, identify the risks that may affect its accuracy, appraise the EPC process in detail, and develop potential recommendations for the future delivery and use of EPCs'

In achieving this aim, the objectives are to:

1. Understand the current context of the EPC, and its uses by different stakeholder groups.

2. Identify the risks to the accuracy of EPCs by understanding the assessor perspective.

3. Explore the process of EPC delivery through a designed research approach looking specifically at variation determined by practice between asessors during the assessment process.

4. Identify possible improvements in the energy assessment process, as well as effective uses for the EPC and future avenues of research.

Inherent in this is the connection between the energy assessor, and the energy performance certificate, and while the study focus has been bounded such that the EPC software *model* sits largely beyond its remit, the EPC model and the DEA that uses it interact, and both EPC and DEA therefore form a central role in achieving the research aim. Like much of the literature concerning itself with models which purport to measure residential energy demand, often criticised for focusing on the phenomenon in too technical a manner (Crosbie & Baker, 2010; Lomas, 2010) and not acknowledging (at least to sufficient extent, it is argued) the interaction between *people* and technology, to understand EPC variation, studying the RdSAP model alone is not sufficient. A study of the EPC in combination with the DEA, the researcher asserts, will shed more light on variability.

It is in this context, with this research aim and these objectives in mind, that this chapter proceeds as follows:

- To define research, then
- To explore research paradigms, and philosophical assumptions.
- Then, a theory is developed,
- A philosophical position is adopted, and
- Research methodologies are identified, selected, then refined to fit the research topic.

The chapter will end with discussion about:

- Validation strategies,
- Ethical considerations, and
- The researcher's position.

Finally, there is an introduction to the case studies themselves, which follow this chapter.

3.2 DEFINING RESEARCH

Shuttleworth (Shuttleworth and Wilson, 2019) defines research as:

'including any formal gathering of data, information and facts for the advancement of knowledge.'

Most research, regardless of whether it is scientific, historical, economic etc. will require a degree of interpretation and an opinion from the researcher at the outset. The notion of a hypothesis will shape the research process: the literature review, the methodological process, case study and conclusions. It is the forming of this hypothesis which, while essential, must be carefully considered so as to mitigate against bias, and ensure the discovery of 'new information (and/or) understanding' is balanced and legitimate. Confirmation bias must be guarded against. 'Being critical, even skeptical, (in the pursuit of knowledge) rather than merely accepting, is essential' (Fellows and Liu, 2015).

It follows that identifying a personal philosophy is essential both in order to form a coherent hypothesis worthy of research and embark upon a methodological approach. This may first involve understanding research paradigms, or the 'worldview assumptions', or 'philosophical worldviews' that the researcher has (Patton, 2002; Creswell, 2009). The research paradigm will affect how the research question will be translated into practice: how data is collected and analysed, and ultimately the results. As such, this chapter proceeds first with an exploration of research paradigms, the researcher's philosophy, and their approach to the question.

3.3 RESEARCH PARADIGMS

The term 'paradigm' is used to refer to the philosophical assumptions or basic set of beliefs that guide the actions and define the worldview of the researcher (Lincoln et al., 2011). The term was introduced by Thomas Khun (Khun, 1970), who used it to refer to shared general beliefs or values of specialists when referencing the nature of reality and knowledge. A 'worldview' is often used as a synonym for a paradigm, described by Patton (Patton, 2002) as 'a way of thinking about and making sense of the complexities of the real world'. Paradigms are essentially philosophical in nature, and all may share the following components (Kaushik and Walsh, 2019; Creswell, 2009):

- Axiology: how the researcher construes values and morals in research,

- Ontology: assumptions about the nature of reality,
- Epistemology: assumptions about how we understand the world and how we acquire knowledge,
- Methodology: our means of gaining knowledge about the world, and
- Rhetoric: a shared understanding about the language of research

As part of the research process, each paradigm applies these components differently. For example, if one were to present paradigms on a horizontal scale, positivism (or 'postpositivism' - arguably a nuanced version of an otherwise similar world view) would sit at one end of it, as may be seen in the table below. This approach to research is most commonly associated with quantitative methods, and focuses on objectivism, precision, reliability, and replication. The researcher is distanced from the subject, which remains as free from bias as possible. This research process may be described as undergoing a series of related steps, making claims about knowledge based on objectivity, deductive reasoning, and control within the research process (Kaushik and Walsh, 2019; Creswell, 2009; Creswell and Clark, 2013). At the other end of this scale, interpretivism, or constructivism, is typically associated with qualitative methods, where the researcher may study the views and opinions of participants, obtaining subjective meaning and inductively building research from the bottom up (Kaushik and Walsh, 2019; Creswell, 2009). This research paradigm may rely heavily on the perception and interpretation of the researcher, and bias is inevitable, accepted, but acknowledged and recorded. Within this range, spanning from positivism to interpretivism, objectivism to constructivism, other research methods, such as action research and pragmatism (among other paradigms) may be identified. Most action research may be summarised as participatory research. To varying extents, the researcher will actively engage in the research subject, involving themselves with each stage, and using qualitative methods to draw conclusions on - most commonly - social phenomenon. Creswell (Creswell, 2009) argues that this type of research is often associated with the rhetoric of advocacy and change. To end this brief summary, pragmatism is noted. Pragmatism is either anti-philosophical, or philosophically neutral. The focus is on getting results and asking the right questions and adopting the right methodology to achieve those results. As such, all approaches are considered, and ranked based on their merit in achieving the research aim and objectives (Creswell and Clark, 2013).

Creswell summarises the four 'worldviews' discussed in this section in the table below.

Table 3. Adapted from Cresswell's 'Four Worldviews'. Source: Creswell, 2009

Positivism/Postpositivism	**Constructivism/Interpretivism**
• Determination • Reductionism • Empirical observation • Theory verification*	• Understanding • Multiple participant meanings • Social and historical construction • Theory generation
Advocacy/Participatory	**Pragmatism**
• Political • Empowerment issue-oriented • Collaborative • Change-oriented	• Consequences of actions • Problem-centered • Pluralistic • Real-world practice oriented

* the postpositivist paradigm reasserts the positivistic values of objectivity and empirical testing, but acknowledges the position and potential bias of the researcher; consequently that theories may never be verified and finalised but instead, earlier theories may be disproved and transcended by further examination and testing. This paradigm was named by D. C. Phillips (Miller, 2007) after numerous critiques of positivism by philosophers including Comet, Mill, Durkheim, Newton and Locke, and one of the earliest of which came from Karl Popper's 'Logik der Forschung' in 1934 (Cresswell (2009)

Each research paradigm – touched upon only very briefly here - is underpinned by a set of philosophical assumptions, which are discussed in the next section.

3.4 PHILOSOPHICAL ASSUMPTIONS

Each paradigm or worldview is supported by a philosophical, or metatheoretical assumption. These assumptions are ontological at their simplest. Crotty (Crotty, 1998) defines philosophical assumptions at their most basic as '*the part of philosophy that studies what it means to exist'*. In this context, ontology explains the view the researcher has of the world, and consequently the approach applied to their research. To work again with the analogy of a horizontal scale of paradigms, discussed in section 3.3 above, a researcher's view might span from a perception of the world as independent and objective, to the other end of the scale as a world with multiple realities, based on interpretation and assessed subjectively.

Epistemology builds on the philosophy of ontology, taking it a step further. Once the researcher has clarified their (ontological) view of the world, consideration is given to how knowledge is acquired. Crotty (Crotty, 1998) defines epistemology as *'the part of philosophy that is about the study of how we know things'*. To elaborate briefly, epistemology might therefore be concerned with *'the very basis of knowledge – its nature and form, how it can be acquired and how it is communicated to others'* (Cohen, Manion and Morrison, 2007). This again may be where the scale of paradigms can be referred to again: *knowledge*, Cohen asserts, may be hard, objective and tangible, and this requires the researcher to take an observational role, using (typically quantitative) methods such as testing, measuring, calculating. However, knowledge may instead by viewed as subjective, unique, and open to interpretation, and this imposes on the researcher a need to make a choice of methodology based on their pursuit of knowledge lying on one end of the scale, or the other. Any choice may well be dictated, at least in part by the subject matter. Table 3 below lays out in simple form the ontological and epistemological distinctions between the philosophies of positivism and interpretivism.

Table 4. The 'philosophical scale'. Assumptions about positivism and interpretivism. Source: Jorgen Sandberg, 2019.

Metatheoretical Assumptions About	**Positivism**	**Interpretivism**
Ontology	Person (researcher) and reality are separate.	Person (researcher) and reality are inseparable (life-world).
Epistemology	Objective reality exists beyond the human mind.	Knowledge of the world is intentionally constituted through a person's lived experience.
Research Object	Research object has inherent qualities that exist independently of the researcher.	Research object is interpreted in light of meaning structure of person's (researcher's) lived experience.
Method	Statistics, content analysis.	Hermeneutics, phenomenology, etc.
Theory of Truth	Correspondence theory of truth: one-to-one mapping between research statements and reality.	Truth as intentional fulfillment: interpretations of research object match lived experience of object.
Validity	Certainty: data truly measures reality.	Defensible knowledge claims.
Reliability	Replicability: research results can be reproduced.	Interpretive awareness: researchers recognize and address implications of their subjectivity.

Axiology is a philosophical term which refers to the role that a researcher's values play in designing their research. Shuttleworth (Shuttleworth and Wilson, 2019) define axiology as 'the theory of values, moral or aesthetic'. The process chosen to collect data might give an indication as to the philosophical stance of the researcher, as well as their axiology. The decision, for example of the researcher attempting to maintain an objective, independent stance about their inquiry, would contrast with a decision to make a key contribution to the work by interpreting the results obtained. The way researchers think about the choices available to them defines their worldview, and this impacts on their research. It may be argued that the only serious potential pitfall for the researcher is inconsistency of approach. However, in reference to Sandberg's table above, while the competent researcher must understand the principles here in order to ascertain the extent to which their views align with one or other camp, their philosophical and axiological position may not easily fall into either camp. Fortunately, the decision does not have to be binary, and the researcher may choose to shun the positivist, interpretivist debate in favour of a different approach. This is discussed in conjunction with the development of a theory, in the section below.

3.5 DEVELOPING A THEORY

The development of a theory must be considered prior to the selection of a methodology. This is because the theory underpins the methodological process, and the two must align with one another. Much in the same way as the scale of paradigms were discussed in the section above, theory may too be said to sit on a horizontal scale. At either end of this scale sit: *deductive,* and *inductive,* theories. A third form, *abductive* theory testing may sit at some point in the middle. Miner (2007) supports this, suggesting that it may be 'more useful to think of theories as falling at points along a deductive-inductive continuum than as falling into distinct categories'. Each of the three theories that sit along this continuum may be summarised briefly as follows:

- Deductive reasoning is associated with a positivist approach and involves testing an *existing* theory. Deduction may be described as a 'top down' approach to research. A theory that is deducted may typically involve the collection of data, followed by the application of rational thought and logic to determine the 'truth'.

- Inductive reasoning would be seen as sitting at the opposite end of the scale and takes an interpretivist ‘bottom up’ approach to theory development. Rather than a fully coherent theory, this approach might instead begin with observation, either of existing, or of newly created data, from which a theory might emerge. As the research continues, theory development is honed, and new tests are conducted to further improve the robustness of the hypothesis.
- Abductive reasoning involves deciding what the most likely inference is that can be made from the available data, or observations. This approach may be taken where there is a loose hypothesis, and a range of potential explanations, or premises for it, all of which may be plausible, possibly to varying degrees. As such, it may be seen to sit in the middle of the scale with inductive and deductive reasoning at each end, drawing to varying degrees from each theoretical approach. The collection of data may be formulated to create a framework which can be molded for testing and re-testing in order to drive further research or reach tentative conclusions (Miner, 2007; Saunders et al., 2016). By way of a simple example, where deductive reasoning may begin with a well-defined hypothesis, and inductive reasoning may begin with no clear hypothesis at all, abductive reasoning may begin with identification of a phenomenon, and set about exploring it. Exploration using abductive reasoning may typically involve using more than one method, or multiple applications of the same method, in order to identify the most likely explanation, followed by the second most likely etc., applying the necessary rigour until a body of evidence sufficient to make a compelling argument is generated.

Deductive and inductive reasoning have obvious shortcomings. For example, exploring a theory with a binary aim of either proving it or otherwise through a process of testing may firstly only be as effective as the testing regime put in place. Secondly, even with a comprehensive methodological procedure, anomalous results may not be wholly accounted for, as a deductive, positivist approach functions best when a theory may only be proven correct, or incorrect. On the other hand, inductive approaches to research are only as robust as the data that is collected, and conclusions are always limited with the caveat that (the strong likelihood is) not all the available data has been scrutinised, and larger samples of data may yield different results. To link back to the earlier section, abductive reasoning may be said to sit in the middle of this scale because reasoning may move back and forth between deduction and induction. To this end, the abductive approach is typically associated with pragmatism, because the researcher is actively involved with two important functions: the ‘bottom up’, and the ‘top down’ approaches, or the analysis of existing data (or the creation of new), and the production of a hypothesis.

3.6 RESEARCH PHILOSOPHIES

This research is intended to establish the existence or otherwise of EPC variability, and support the development of a more efficient surveying process. In achieving this, the primary function here is to analyse the system of assessing energy efficiency in residential property as it is undertaken currently.

The study investigation begins at a point noted above where anecdotal evidence has been collected that would suggest there may be a degree of variability to assessments, and that outputs are not necessarily as reliable as might be expected (Gledhill et al., 2016). As such, a loose hypothesis is in place from an early point in the research. Some qualification of this assertion may be the way forward, specifically to establish whether or not this variability really exists, and if it does, how it might come about.

An appropriate starting point as mentioned above might be to gauge the opinion of those qualified DEAs currently working in this area. This may be considered something of a necessity if it is to be asserted with any authority that there are issues with the energy assessment process at all. However, while the gauging of DEA opinions might form a valuable insight and may be appropriate in terms of scope for the first part of this study, it may not be considered sufficiently robust to satisfy the researcher’s wider aim of pointing to variability within the energy efficiency surveying process, and supporting an improved process going forward. In order to achieve this, numeric survey data must be collected from a controlled environment and analysed.

Gill (Gill and Johnson, 1997) discussed PhD level construction management research projects, suggesting they may be broken down into three distinct areas:

Type 1: research is undertaken to investigate an identified or forecasted phenomenon. Here, the research topic is focused, the parameters defined, and the purpose is to produce an answer to a pre-existing question.

Type 2: research is undertaken in continuum with an already established research area. This may extend an existing piece of research or be linked with existing research. The research topic may be less well defined than in Type 1, and the final destination uncertain.

Type 3: research is undertaken on an exploratory basis, conducted in real time and with uncertain outcomes. This may be seen to reflect a wide variety of research projects, including this particular project.

It is challenging to categorise research projects in this way, even when the categories relate to a relatively narrow area of research, but this may be considered a start, albeit a basic start to the process of choosing a methodology for this research. Notwithstanding the above, within which the research here may most easily sit within Type 3, the research method may also be dictated by whether the research can be categorised as positivist, interpretative, deductive, or inductive. This is discussed earlier in this chapter, but may be elaborated upon with an example by quoting Spradley (Spradley, 1980) who compares positivist and interpretivist researchers to engineers and explorers:

'The engineer has a specific goal in mind; to find oil or gas buried far below the surface. Before the engineer even begins an investigation, a careful study will be made of the maps which show geological features of the area. Then, knowing ahead of time the kinds of features that suggest oil or gas is beneath the surface, the engineer will go out to find something specific. (Spradley, 1980, p26).

Positivist research methodologies emphasise the importance of grounding research in systematic technique (Spradley, 1980). This may be seen as a process of testing hypotheses with scientific rigour, resulting in the increasing robustness of a causal argument, for example 'A causes B, or A's variation results in the variation of B'. Interpretative research methodologies may be typically derivative of the social sciences, requiring analysis of interviewee's accounts, or of observations or conversations, to gain understanding, though not necessarily to provide a concise explanation or a specific conclusion. A basic summary table of deductive and inductive methods of research, reflecting the positivist and interpretive positions at each end of the scale as discussed earlier in this chapter, is displayed below.

Table 5, showing a comparison of deductive and inductive research methods. Source: Gill & Johnson, 1997, p37

1. Deduction	vs.	Induction
2. Explanation via analysis of causal relationships	vs.	Explanation of subjective meaning
3. Generation and use of quantitative data	vs.	Generation and use of qualitative data
4. Use of various controls, physical or statistical, to allow hypothesis testing	vs.	Real world research, attempts to minimise reactivity among the research subjects
5. Highly structured to ensure replicability of 1,2,3, & 4	vs.	Minimum structured to ensure 2,3, & 4 (and as a result of 1)

Lab experiments	Quasi experiments	Surveys	Action research	Ethnographic study

As touched upon in the theory section (3.5) above, a typical research project may not be quite so binary as Table 4 above would infer, and even in the case of a research project with one clear aim and one clear methodological route required to achieve that aim, there may be some cross over between deduction and induction. This is where abduction (noted in the section above), and pragmatism may be a consideration. Pragmatism, as touched upon earlier in this chapter, may be said to require a degree of both induction and deduction. Dewey (Dewey, 1933) conceived a five-step model for understanding problem solving, which was later revised by Morgan (Morgan and David, 2014) to illustrate a system of pragmatist research methods. These steps are briefly explained below, and coupled, also briefly, with an explanation of the research process undertaken here:

1. The first step involves encountering a situation and recognising it as a research problem, with the problem lying beyond the researcher's current range of experience. Consequently, the researcher would not have any clear response to the problem.
    - Here, this was the noting of variation in EPC outcomes in properties with seemingly very similar attributes, noted by the researcher within his normal working duties, managing a team of DEAs. This was reflected upon within the breadth of professional experience the researcher had, which he

considered insufficient to tackle the conundrum. This triggered the study process.

2. The second step would require reflection on the nature of the problem, considering this within the researcher's existing beliefs. The process of reflecting may sometimes lead to developing new versions of the problem and revisions of the original research question.
    - This period of reflection began once the academic research programme was underway. Within the study programme, the researcher had was able to reflect on the conundrum more widely. For instance, sometimes hundreds of EPCs would be available for (at least partial) scrutiny each month. EPCs for similar houses, flats, bungalows, produced by different DEAs could be compared with one another. Site based re-inspections could be undertaken by the researcher, and feedback could be gleaned from, and given to the DEAs undertaking the EPCs. The raw data collected by the DEAs could be manipulated in the software model used to generate EPCs, and the researcher could look into the particular inputs that varied most, and from which DEAs these came. This allowed the researcher to refine the research question – things like which EPC variables were of key importance, and what impact they had – at an early stage.

3. The third step involves considering possible actions: thinking about the possible ways to address the question and the potential research design.
    - This period lasted some time. Early in the research process, the researcher submitted a journal paper (Gledhill, 2016) whose focus was on key EPC variables, and their impact on EPC outcomes when manipulated in the EPC (RdSAP) software model. This helped guide the researcher toward a mixed methods research design which is discussed later in this chapter, in short because a single, quantitative approach scrutinising the impact of varying EPC inputs on outcomes – while forming a case for further research – would not answer a key part of the researcher's question. The paper hypothetically set out to prove how EPC variation *could* occur in theory but did little for whether this *actually* occurs in practice, and nothing at all in answering why

this variation might occur. This helped lead the researcher in a particular direction of research design which is discussed later in this chapter.

4. At the fourth stage, the researcher would reflect on the choice of research methods and think about the best methods to address the research question. As a result of this process, the researcher may take a step back, as thinking about the choice of methods may bring the research back to revising the choice of research design, which may in turn lead to a reconsidering of the research question. Pragmatists describe this process as the *abductive* process, discussed earlier in this chapter. Morgan describes this as an 'if, then' relationship, where '*if* you act in a particular way, *then* you are likely to produce a specific set of outcomes'. Therefore, pragmatist methodologies lead to the reflection of the nature of the problem and its potential solutions, and on the nature of the solutions and the likely actions. To put this another way, the methodology connects the process of designing the research to the core research question and connects the design concerns to the choice of methods, so research design plays a crucial role in bridging the gap between research questions and research methods.
    - The researcher established a suitable methodological approach as part of the study process outlined in part three of Dewey's five stage process, above. This was underpinned by the researcher's ontological and epistemological stance, and following this, consideration was then able to be given to which research methods will achieve the most robust results. This is a process which is discussed later in this chapter.

5. The final stage involves actually carrying out the research.
    - The study results are to be found in the following chapters of this research.

It is important to note that as simplistic as Dewey's and Morgan's step by step process is, the process of decision making is complex, requiring the researcher not only to be guided by their beliefs, but to be consistent and methodical in their approach to their research.

It is after some reflection on the philosophical approaches discussed in the sections thus far that the author has adopted a pragmatic view and abductive approach to the research question, as it is considered this may be best aligned with his beliefs, and most appropriate to the research.

3.7 RESEARCH STRATEGIES

McGrath (McGrath, 1982) categorised research 'strategies' into eight distinct types: formal theory, sample surveys, laboratory experiments, judgement tasks, computer simulations, experimental simulations, field studies and field experiments. These may be compartmentalised further to fit with three broad research strategies outlined by Yin (Yin, 1994):

- Experiments: measuring the effects of manipulating one variable on another
- Survey: collection of information in standardised form from groups of people, and;
- Case study: development of detailed, intensive knowledge about a single 'case' or of a small number of related 'cases'.

As touched upon earlier, for this research, the decision is not binary if the aim and objectives are to be achieved. The first 'experiments' bullet point may – as in Dewey's third pragmatic step in the section above – be seen as indicative of Gledhill's (Gledhill et al., 2016) paper on the research topic. To reiterate briefly, in this paper, hypothetical data was manipulated within the EPC in order to monitor the effect on outcomes, and these effects were discussed and a case for further study put forward. As the research has developed, Yin's second bullet, the 'Survey' may be likened to a stage of research here where the interview material is collected to gauge the view of DEAs themselves on the issue of variability. The site based EPCs that are designed to establish the existence of otherwise of variability itself could be argued to fall into either 'Survey', or 'Case Study' categories. This muddying of waters presents a challenge when adopting a methodology: a single methodological approach will not be appropriate when the research project clearly extends beyond any one categorisation of research strategy by established authors and brings the researcher back to the pragmatic approach.

With a pragmatic approach established, and with the forming of a loose framework for enquiry into the research question, the research problem may be best suited to mixed methods research where, as noted earlier in this chapter, more than one phase of research is commonly undertaken, and both qualitative and quantitative data may be collected and analysed. The methodological approaches are discussed further in the next section.

3.8 MIXED METHODS RESEARCH

It could be argued that early definitions of mixed methods research tended to view it as quite prescribed: Greene (Greene et. al., 1989) defined mixed methods as *'those that include at least one quantitative method (designed to collect numbers) with at least one qualitative method (designed to collect words)'*. As mixed methods became more widely adopted, so did researchers develop and loosen its initially prescribed nature, so that Tashakkori & Teddlie (Tashakkori and Teddlie, 1998) described mixed methods as having *'evolved to the point where it is a separate methodological orientation with its own world view, vocabulary, and techniques'*. In 2007, mixed methods were synthesised into a composite understanding by Johnson (Johnson et. al., 2007) based on nineteen different definitions provided by twenty-one published mixed methods researchers. Pragmatist research and mixed methods are synonymous with one another. The pragmatic approach often uses mixed method strategies in order to soften and broaden the limited scope for flexibility in quantitative and qualitative studies. Pragmatists will select their methodologies and data collection methods based on the research question, including the setting, participants, and potential outcomes (Saunders et al., 2016). In the opinion of the researcher, the research question here can be divided into two quite distinct but interrelated phases which are described and justified later in this chapter, but may in short include a qualitative element that looks to clarify the research hypothesis with practising DEAs, and, after some analysis and interpretation of the results, a more carefully tailored follow-up quantitative phase, which may look to provide some hard evidence to support the hypothesis, post-qualitative clarification. The principles of this research approach are looked at in some more detail next.

3.9 JUSTIFICATION FOR A MIXED METHODS APPROACH

Creswell and Plano Clark (2011) suggest that researchers consider starting with a typology-based approach to mixed methods design. Typologies can provide a relatively straightforward basis upon which to break down a research question, potentially offering some guidance in choosing an appropriate methodology for use in conducting research. Greene (Greene et al., 1989) provided a relatively simple framework (in comparison with later frameworks) in the form of five key typologies that might be reflected upon when considering mixed methods research. In working toward a decision to adopt mixed methods research, a table was created with Greene's five typologies, populated with an interpretation of the how these might look when applied to the research question posed here. This table is presented below:

Table 6. Five Typologies for Mixing Methods, adapted for the research question 'A Study into the Variability of UK Energy Assessments'. Souce: Creswell, J., Plano Clark, V., 2011.

Greene, Caracelli & Graham (1989) Five Typologies for Mixing Methods, referenced against the research question 'A Study into the Variability of UK Energy Assessments'	
Triangulation (seeks convergence and corroboration from different methods)	The philosophy of triangulation is consistent with the emerging pragmatic view of the researcher, whereby material taken from a number of different sources (i.e., literature, professional experience, critical theoretical analysis and now interview and site survey data) are contrasted with one-another to add weight to a hypothesis. The ability to be able to triangulate information effectively is enhanced by using a mixed methods approach, as data drawn separately from different research methods can be cross referenced.
Complementarity (seeks elaboration and illustration from the results of different methods)	Qualitative and quantitative research methods can be compared and contrasted, to establish themes that cross the research method genres, potentially producing more comprehensive conclusions, and in some cases drawing conclusions that would not otherwise have come to light if conducting only one research method.
Development (seeks to use the results of one method to help develop or inform the results of another)	This theme is vital to the mixed methods approach and constitutes another key reason why the approach was considered most appropriate in addressing the research question posed. Development in this context is about beginning with a hypothesis that is not fully formed, and for which an empirical, quantitative study at the outset would not be appropriate without first gauging opinion based on the experience, in this case, of practising DEAs. It is considered appropriate that analysis of the interview material should take place first in order to establish greater clarity and feed into the approach for the second research phase.
Initiation (seeks the discovery of contradiction or	There are only twenty interviewees for this first phase of study, and while the selection process, outlined later in this chapter, may be considered robust and representative of the wider DEA profession in many respects, this is far from guaranteed with a relatively small sample

paradox, or new perspectives or frameworks when comparing one method with another)	such as this, and indeed the experience of DEAs interviewed may be greater than that found across a wider sample: this is noted as a limitation later in the chapter. The process of initiation during mixed methods study may uncover contradictions, inconsistencies or simply unexpected results when comparing interview material with subsequently collected quantitative data, and it is important to acknowledge and record this where it exists, and try to explain it.
Expansion (Seeks to extend the breadth and range of inquiry by using different methods for different components)	It may be considered unreasonable to extrapolate data collected from twenty interviews to be representative of the profession as a whole. The theory of expansion is that wider conclusions can be drawn based on the extended breadth of two studies, undertaken using different methods. While only inferences can be drawn at the first stage, and preliminary conclusions mooted, more robust conclusions can be drawn once both strands of research are fully complete.

Table 6 above might be considered compelling when drawing the conclusion that mixed methods would be a suitable tool to apply to the research question posed here. But, as discussed earlier in this section, there are a number of different forms of mixed methods research, and the next step might be to establish which form best suits the research question. Cresswell and Plano Clark (Creswell & Plano Clark, 2011) describe the qualitative and quantitative elements of mixed methods research as 'strands', and proceed into discussion about how these two strands may interact. In doing so, they quote Greene (Greene, 2007), who argues that this interaction may be described in two keyways: *independent* interaction, and *interactive* interaction. Interactive interaction is described as occurring when a direct interaction exists between quantitative and qualitative strands of study, and through this interaction, the two methods are mixed, potentially at a number of points, before final interpretation. The research method proposed here sits more comfortably in the camp of the former, independent interaction. This occurs when the qualitative and quantitative strands are implemented so that they are independent of one another, so that each strand, along with their respective analysis is kept separate. The two strands are then mixed when drawing conclusions during the overall interpretation at the end of the study, a point described as 'the point of interface' by Morse (Morse and Niehaus, 2009). This would allow for the DEA interview material contained here to be analysed separately first, with the results feeding into a quantitative follow-up study which could also be analysed separately, before synthesising the two sets of results. This procedure might be used to good effect because the human, text-related strand of the research question can be compared with numeric survey data from strand two, to see where there are consistencies, or if there are contradictions. Greene also discusses the timing of each strand, where implementation can occur either concurrently, sequentially, or as part of a multi-phase approach. The approach considered most appropriate here is that of sequential timing - a sequence - allowing the qualitative study to be undertaken within an initial study, the results of which can be digested and fed in to the second quantitative strand, thereby offering up the best possible opportunity to design an effective method of inquiry that may most comprehensively address the research question. Also, for a single researcher, the fact that this is probably the most convenient process by which to undertake the two strands should be acknowledged.

3.10 MIXED METHODS RESEARCH DESIGN

After having established the overarching research methodology that might best suit the research proposal, as well as the methods that may most effectively be adopted, the research sequence, or research *design* may be finalised. Jeff Sauro (2015) noted three prototypical versions of mixed methods research, the ‘convergent parallel design’, the explanatory sequential design’, and the ‘exploratory sequential design’. These methods are presented in flow-chart form below:

Figure 28: Explanatory Sequential Design. Research methods are undertaken sequentially here, with the quantitative method undertaken first. Source: Jeff Sauro, 2015

Figure 29: Exploratory Sequential Design. Research methods shown to be undertaken sequentially, with the qualitative study coming first. Source: Jeff Sauro, 2015

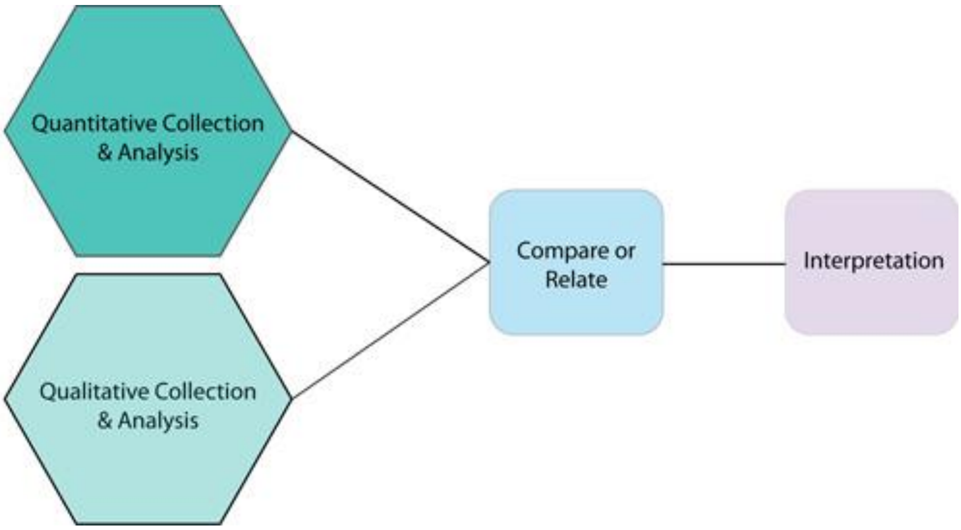


Figure 30: The Convergent Parallel Design. Showing both qualitative and quantitative methods being undertaken concurrently, with comparisons and then interpretations drawn together afterwards. Source: Jeff Sauro, 2015

As one might deduce from the description of the research proposal in a research design context thus far, the Exploratory Sequential Design approach is the most appropriate here, and this is the design adopted. Like the Exploratory design, the Explanatory design also occurs in two distinct phases, but the data collection phase comes first in this approach, which would not suit the research proposal here as there is yet to be an issue of variability established, and both this, and the potential reasons for variability may begin by way of qualitative, DEA interviews. It is the exploration of this interview data, coupled with the initial research hypothesis that have in this case brought up material that can feed in to create a more targeted quantitative study, for example by analysing why inaccuracies come about and what the cause of these inaccuracies may be.

3.11 THE EXPLORATORY SEQUENTIAL DESIGN

The exploratory sequential design, also referred to as the instrument development design, and the quantitative follow-up design (Creswell et al., 2004, Cresswell, 2009, Morgan, 1998), allows the researcher to develop an instrument, or system for quantitative study based on a qualitative exploration of a topic. To contextualise this, the aim here might be to qualify the assertions made by DEAs during semi structured interviews, the results of which may help to inform a larger study of EPCs undertaken by a number of DEAs at a control property/ies, based primarily on the collection of numeric data. At the outset, this might be described philosophically as a constructivist approach, as the tacit knowledge, thoughts and experience of DEAs are analysed by the researcher, but as the method progresses into its quantitative strand, or as this thesis reaches its end, a more post-positivist philosophy is adopted. This is because material has been uncovered here that would triangulate with an early, theoretical study (Gledhill et al., 2016), and some early conclusions may begin to be drawn, setting the researcher along the path of a developing, hardening theory. Thus, more than one philosophical view (or a developing epistemology) is taken as the research unfolds, and the post positivist view may be considered consistent with the latter stage of the exploratory sequential research design chosen here, as both seek to triangulate multiple sources of information in order to confirm a (albeit acknowledged as potentially fallible) theory. As there is no guiding framework or theory for the variability of EPCs, and as the variables are not clear, it is considered most appropriate to establish as much of this as possible by way of DEA interviews, thus developing a constructivist philosophical stance here that can be tested further at the second strand. It is when both strands are complete that the results of the DEA interviews here may be empirically tested, triangulated and cross referenced, and only at this stage can some degree of legitimacy be given, depending on outcomes, to stratifying results out and potentially making some generalisations about the wider world of surveying for energy efficiency, though the researcher’s philosophical approach is itself noted as a source of potential weakness in the presentation of the findings of this research.

3.12 RESEARCH METHODS

While a research philosophy strategy, design and approach have emerged, the technical aspects of the research are still to be established. Both the research methods, and the methodology within which they sit must still be identified. With methods, the methodological manifestations of the positivist and interpretivist philosophical positions may be described as quantitative and qualitative methods. The distinction between quantitative and qualitative methods may in simple terms be attributed to their flexibility. Generally, quantitative methods may be regarded as highly structured and inflexible. Researchers will pursue objectivity, and use data, tables, graphs to present trends, relationships, findings. Quantitative research methods may include (Mack et al., 2005):

- Descriptive research,
- Correlational research,
- Causal-comparative research, and
- Experimental research

Conversely, more flexible qualitative methods can allow for greater spontaneity and adaptation of the interaction between the researcher and the study participant (Mack et al., 2005). They may be used to explore socially constructed, subjective topics where themes and generalisations are likely to emerge, as opposed to specific, often numeric outcomes. As can be seen from the extract below (Mack et al., 2005), quantitative and qualitative approaches broadly align with the positivist and interpretivist paradigms. Qualitative methods may include:

- Action research,
- Case research,
- Grounded theory,
- Narrative research,
- Ethnographic research, and among others,
- Phenomenological research.

Table 7. A comparison of quantitative and qualitative research approaches. In reference to this study, note in particular the highlighted section marked ‘Analytical Objectives’ where both quantitative and qualitative approaches may be seen to support the research aim here (see the opening remarks of this chapter). Source: ‘Qualitative Research Methods - A Data Collector's Field Guide’, Mack, Woodsong, MacQueen, Guest, Namey, 2005

	Quantitative	Qualitative
General framework	Seek to confirm hypotheses about phenomena	Seek to explore phenomena
	Instruments use more rigid style of eliciting and categorizing responses to questions	Instruments use more flexible, iterative style of eliciting and categorizing responses to questions
	Use highly structured methods such as questionnaires, surveys, and structured observation	Use semi-structured methods such as in-depth interviews, focus groups, and participant observation
Analytical objectives	To quantify variation	To describe variation
	To predict causal relationships	To describe and explain relationships
	To describe characteristics of a population	To describe individual experiences
		To describe group norms
Question format	Closed-ended	Open-ended
Data format	Numerical (obtained by assigning numerical values to responses)	Textual (obtained from audiotapes, videotapes, and field notes)
Flexibility in study design	Study design is stable from beginning to end	Some aspects of the study are flexible (for example, the addition, exclusion, or wording of particular interview questions)
	Participant responses do not influence or determine how and which questions researchers ask next	Participant responses affect how and which questions researchers ask next
	Study design is subject to statistical assumptions and conditions	Study design is iterative, that is, data collection and research questions are adjusted according to what is learned

3.12.1 Qualitative research methods

Qualitative research methods are categorised and discussed below to help the reader understand the decision making process and method adopted by the researcher:

Action research puts an emphasis on practical outcomes, that may emerge from research ‘in action’, rather than ‘about action/s’ (Saunders et al., 2016). The process is interactive, and Saunders describes it as a system: ‘diagnosis, planning action, taking action, and evaluating the results'. Here, the researcher works to facilitate the outcome/s, which can be time consuming and intensive.

Case research centres on a specific occurrence, for example an event, process, person, or group. Case studies can be wide ranging in type, using qualitative or quantitative methods or mixing them, and broadening to study many events, or just one, in varying levels of detail sufficient to satisfy the research question. The outcome of a case study will define what occurred, what effects it had, and the implications for the future (Saunders et al., 2016).

Grounded theory is an inductive strategy which starts with data, and develops and observes the processing of this data, and/or the generation of more data to formulate a theory. Sampling is used throughout the study process, and an interactive process is established that compares new data with established, original data. Codes and categories are created to organise the process and present findings. These codes and categories will be refined and altered throughout the process. It is when codes and categories no longer need to be refined in light of new data that a saturation point is reached, and new theories and themes can be drawn from the research process (Saunders et al., 2016).

Narrative research, as the name would infer forms a story, about the lives of individuals. These stories might typically focus upon key events in an individual or group's life. The researcher is likely to be personally involved in the work, meeting and interviewing the subject/s, and gathering information about them, potentially by interviewing others, or through the collection of photographs, artefacts etc during the course of the research (Creswell, Plano Clark, 2011).

Ethnographic research is concerned with the study of social groups and cultures. Here, the researcher will engage fully with the group, interacting with them throughout the study. The researcher may lend particular focus on the culture of the group, including for example their beliefs, religion and rituals. The study would be presented in full cognisance of the researcher's own interpretation of events, and so the researcher's own background and experiences would be recorded so as to mark the subjective nature of the narrative (Saunders et al., 2016).

Phenomenological research centres on the experiences of individuals who have similar backgrounds, experiences, understandings or knowledge. Participants will face open ended interviews – usually face to face with the researcher – in order that the researcher may glean detailed and often lengthy descriptions of their subject matter. Typically, these might include subjects recalling experiences, interpreting events, or giving insight or opinion on a specific matter. The researcher must then interpret these with a view to generating themes and meaning. As with narrative and ethnographic research in particular, the researcher here will need to record and reflect upon their own role in the process in order to be as balanced and impartial in their interpretations of the material as possible. Outcomes may be complicated and open ended, and are likely to highlight possibilities for continued research (Creswell, Plan-Clark, 2011)

3.12.2 Qualitative research method selected

The phenomenon identified by the researcher at the outset and loose hypothesis which if followed would lend itself best to the case study approach, where the dynamics of the EPC *process* may be studied to identify if variability exists, why it might exist, and if so, what effects variation has and what the implications of this variation are.

3.12.3 Quantitative research methods

- **Descriptive research** looks to describe the status of a variable. This type of research project is designed to provide systematic information about a research phenomenon. A loose research hypothesis may be in place, but this is not essential, as the hypothesis emerges upon collection of the data. Careful selection of the study unit/s and measurement of each variable are required to provide robust data.
- **Correlational research** aims to determine the relationship between a number of variables, as opposed to descriptive research, which may traditionally focus on the status of a single variable. Correlational research will identify trends and patterns in data, but would not usually go so far as to identify categorically the cause for these patterns: cause and effect would not typically trigger the correlational approach. Here, the data, their relationships with each other, and their distribution would be studied, but not manipulated.
- **Causal-comparative research** establishes cause-effect relationships. Here, an independent variable is identified but not manipulated, and its effects on a larger group are measured. Groups are not randomly assigned, but naturally formed and

comparisons are drawn between variable groups that are identified against those groups that are not.

- **Experimental research** is often described as true experimentation. This will use a traditional scientific method a cause – effect relationship among a group of variables. This may typically be likened to a laboratory study, but need not be. The setting for the research is unimportant.

3.12.4 Quantitative research method selected

In this study, while taking a pragmatic approach, the descriptive method of quantitative study may best facilitate the research. To put this into context, this would involve the scrutiny of a number of variables (the justification for the selection of these will follow) in site-based EPC data, in order to better understand and draw inference from – though not categorically confirm the reasons for – the relationship between EPC inputs and outcomes, and the distribution of EPC outcomes. It may be interesting as part of a separate study to take the research a step further using the causal-comparative method or experimental research method and compare or even manipulate EPC data inputs to study their impact when other variables remain either static or equal, but this lies beyond the scope of this research.

3.12.5 Data collection for the qualitative research strand

Data collection methods need not be specific to qualitative or quantitative research, and there is plenty of overlap, although the procedure may vary dependent upon which approach is taken. Interviews, for example, when used in qualitative research may take a more open ended, less structured approach, but may in contrast be short and closed for use in quantitative research, so that more mathematical scrutiny of the collected data may be facilitated. Below is a selection of data collection methods typically used in qualitative research, that may be applied to the research question posed here.

- **Focus groups** give the researcher an opportunity to involve multiple participants in an active conversation with the researcher and each other, often involving debate and argument, or consensus and agreement, with the researcher acting as chair, and prompting where necessary to keep the topic of conversation on track. The format can vary in structure but will usually glean rich and complex data.

This form was not considered suitable for the research topic here due to the potential for a consensus to emerge between participants, or the forming of camps within the group. Individual, independent responses would provide more compelling evidence for variability of EPCs if a consensus emerged, and equally if there was none, the study hypothesis would require revision before proceeding to the quantitative stage, or indeed any further at all.

- **Postal surveys** form a direct method of gaining insight from potentially hard to reach groups – those who may not take part in an interview or focus group. They can be a straightforward way of gathering data, and potentially large samples can be targeted with relative ease. Questions may usually be relatively short and simple in order to avoid confusion and not deter respondents from taking part. The research here may not lend itself well to postal surveys though, because respondents have as much time as they like to consider their responses, potentially guarding them, or fearing written entries may be used against them in future. The surveys could be anonymised but this would not allow any cross referencing with the respondent's academic and professional backgrounds, which was perceived as potentially valuable here (see Chapter 4). Also, immediate, candid responses were considered more appropriate to the research aim. Finally, poor respondent participation is common.
- **Observation**, including **controlled, naturalistic and participant observation**, is an important method of carrying out both qualitative and quantitative research. Naturalistic observation, and its close variant participant observation might be most closely linked with qualitative research. These techniques involve observing the spontaneous behaviour of participants in their natural surroundings; the latter as the term might infer, involving researcher participation in the observed group. These techniques may most often be the method used for ethnographic research. The technique is unstructured and would not be appropriate here in deriving answers to the hypothesis posed, as some form of discussion with DEAs seeking their opinions, and scrutinising the data they collect on site, as opposed to watching them carry out their duties may be of greater use.
- **Online surveys**. The attributes both for and against online surveys may be broadly similar to those of postal surveys, discussed above.

- **Unstructured interviews** - the most flexible type of interview. These can be unpredictable and may allow the respondent to digress but can work if the researcher wants to understand a very specific topic in great detail. Essentially a conversation, the researcher will ask a question and the participant will respond, importantly without further prompting, guidance or interruption (so as not to compromise the data by directing the participant). Unstructured interviews are often described as ethnographic interviews (Qu & Dumay, 2011).
- **Structured interviews** may be seen as the most appropriate way to obtain concise material from participants. They work well when used in instances where specific responses are needed from a limited range of categories. This type of interview can lack depth, as participants are often unable to elaborate on the short replies they are encouraged to give (Qu & Dumay, 2011, Creswell & Plano Clark, 2011).
- **Semi-structured interviews** form a combination of structured and unstructured interviews. Qu & Dumay (2011) assert that these are the most common method used in qualitative research. Questions are outlined and sequenced ahead of the interviews themselves, based on an existing theme or hypothesis. The process allows for a good degree of flexibility, as direct, structured responses from respondents can be obtained, but then built upon with some justification and reasoning from respondents. Unlike unstructured interviews, data can be limited in its extent, allowing for a reduced, and less onerous data analysis regime.

3.12.6 Qualitative data collection method selected

The researcher's pragmatic approach led him to consider semi-structured interviews as the appropriate method, allowing for initially concise data collection and presentation in response to the key question 'does variability exist', but also to obtain the thoughts from DEAs as to why this variability might exist. Here, the researcher can present headline responses about EPC variability, and also point to the reasons given for this, which will guide formation of the second stage of research. From a practical point of view, this also allows the researcher to manage the data analysis stage within the study remit.

3.12.7 Data collection for quantitative research

As noted in the section above, data collection methods need not be specific to qualitative or quantitative research, and there is plenty of overlap, but in the interests of organising and categorising this research process, the options for the types of quantitative research data collection methods that may be applied to the question posed here are set out below.

- **Structured interviews** are discussed in the section above, and while more commonly associated with qualitative research, may also be effectively used in quantitative studies. The structured approach would usually be undertaken here. However, interviewing will only go so far in answering the research question posed here, and will provide empirical evidence, however weak, for EPC variation. It is not a useful tool for this second strand of research, therefore.
- **Questionnaires**, like interviews, are discussed in the section above, and may not be considered useful here because a) the approach is too similar to that used in the first phase of research, and importantly b) gauging opinion will not provide empirical evidence for EPC variation.
- **Focus groups** may also be used successfully for the collection of quantitative data, and as with interviews and questionnaires above, they are discussed in the last section. This approach was also discounted as being a) too similar to that used in phase 1, and b) not capable of capturing data that would actually *identify* variability, as above.
- **Observation**, including controlled, naturalistic and participant observation, are discussed above. Of the three, one might assert that controlled observations are the most closely linked with quantitative research. These are structured observations, undertaken to a strict procedure in laboratory-like conditions. In these studies, behaviour is often coded, as opposed to being recorded in rich detail is may be the case with other forms of observation. However, while observation of the behaviour of DEAs while undertaking EPCs may draw some interesting results, these results would not be conducive to the establishing or otherwise of variability in EPCs.
- **Experimental research** may be described as that which uses a scientific approach to using two or more sets of variables. A constant, or control might be established, and measurements will take place against this control. The success or otherwise of this type of approach may be based on the quality and consistency of the control. The research would be expected to establish a consistent cause

and effect. The selected quantitative research method draws from the experimental approach insofar as a control is deemed essential if meaningful conclusions are to be drawn, but the experimental approaches, often categorised as ‘pre-experimental’, ‘true experimental’ and ‘quasi-experimental’ are quite rigid designs that do not form a good fit with the material the researcher requires from this second phase of research. The experimental approach may well establish EPC variability, but the approach would not work well with the relatively small numbers of EPCs commissioned or with the large number of individual variables that may need to be set aside, because of the practicalities of the research programme. Variability may be better established by bearing in mind the high standard of rigour that the experimental approach commands, but arranging a bespoke ‘test’ approach that maintains this rigour while appraising the figures in a manner more conducive to the available data and the research question, as discussed in the next section.

- **Tests** are very flexible and may be used to measure a wide range of phenomenon and hypotheses. They may be tailored to a huge variety of tasks, and may incorporate other methods to achieve their aim. The key to a robust and successful testing regime may be in its design and implementation, which is discussed in more detail in Chapters 5 and 6.

3.12.8 Quantitative data collection method selected

Here, a field test was considered the most appropriate way to gauge variability of EPCs, incorporating the experimental approach of using a control. Having concluded this, a tailoring process which is discussed more in Chapters 5 and 6 was carefully put together in order to collect the raw data collected by DEAs after completing an EPC for two, researcher-selected properties.

3.13 DATA ANALYSIS

3.13.1 Semi structured interview data analysis

Initially, a number of data analysis options were considered, and these are broken down and discussed briefly in the following bullets.

- **Coding** of responses was an option, however this was discounted, as it was thought that removing key words from their context and tabulating or re-assembling them would detract from the overall meaning that the DEAs were trying to portray (Le Pelle, 2004). It was considered possible that this would detract from the potential to cross reference this material with that obtained from the second strand of research and would not be fully in keeping with the mixed method approach, and the qualitative nature of this research strand. Grounded theory, developed by Glaser & Strauss during a study entitled 'Awareness of Dying' (Glaser & Strauss, 1967) is designed to generate a plausible theory of the phenomena that is grounded in the data (McLeod, 2001). While a basic version of grounded theory may serve to code and categorise the data in the interviews undertaken here, and finish with an emerging theory, this does not really constitute a grounded theory approach, and it may be seen as challenging to develop a grounded theory approach in the way the method might be intended. These interviews are conducted as part of a two-strand, mix methods exercise. They tell only a partial story in isolation and yet the grounded theory method may be considered quite complex, with a need to appraise data and add to it, or alter the data collection routine, or both, in cycles in order to reach a theoretical conclusion. This level of depth may not be suitable to the interview material here, and the practicalities involved in cycles of sampling would be challenging for the researcher. While the second strand of research, the site based quantitative activity may be informed by this qualitative strand of interviews, this too is not really the grounded theory way, but a pragmatic, mixed methods way. Put simply, the grounded theory method involves collecting, analysing, categorising, and sampling data, *in cycles*, with each layer of analysis informing the next cycle of research. This does not fit with the researcher's study plan.
- **Interpretative phenomenological analysis** (IPA) is a research methodology commonly applied to qualitative material, conceptualised originally during the 1990's for application within the applied psychologies (Smith, 2011). Smith points to the broadening use of IPA by a much wider research base since its inception, but Reid (Reid et al., 2005) indicates that best use of the methodology may be put to analysing more extensive interview transcripts with fewer subjects. He advocated a 'less is more' approach with respect to participant numbers,

inferring that students are often pushed by supervisors to produce more interviews in the interests of achieving statistical robustness, but which contain limited information, as opposed to opting for fewer participants with more extensive transcripts. With twenty interviewees in the research here, and a relatively short question set, hence transcript for each (typically interviews range from fifteen minutes to half an hour) the IPA methodology was not considered a suitable application to this material.

- **Content Analysis** and Discourse Analysis are often cited together as appropriate methodological procedures for analysing qualitative interview material such as that collected here. They are both essentially concerned with the analysis of text and would therefore have to be considered as options for this phase of research. Both may be seen as complementary and mutually supportive in the exploration of social reality, though the two methodologies are actually based in two very different philosophical camps, and beyond the basic premise that they may be employed to analyse text, they actually play very different roles in research. Content Analysis adopts a systematic approach to the text, categorising it into distinct groups for coding, then using a quantitative procedure to dismantle the text to ready it for statistical analysis (Silverman, 2001). This was considered too rigid here; too far removed from the context of the interview material to be considered appropriate. This strand of research was intended to be qualitative, and better fitted to a less rigid, more contextual form of analysis, and so Content Analysis was considered incompatible for this reason.
- **Discourse Analysis** may be described as qualitative and interpretive. Immediately then, this sits more comfortably with the intentions of the researcher for this strand of the study, although it sits less comfortably with the pragmatic stance of the researcher, because it employs a set of techniques for conducting a structured, qualitative investigation such as that proposed in this research (Burman & Parker, 1993). The system is inductive, which could fit with the interview question set here. However, this approach is used more commonly to analyse social, societal and psychological themes, which fall largely beyond the remit of this research. While the ontological stance of the participants, and their epistemology is worthy of discussion, and undoubtedly has influence on the language used and responses given in the interviews, it may not be seen as the

overriding theme for this research. In addition, discourse analysis might ideally be supported by literature (Burman & Parker, 1993). This is seen as new knowledge, for which there is no direct study material that will support it. While this gives rise to the potential for unsupported assertions to be made, this is not necessarily an issue here, because the second strand of research may go some way to proving or disproving their assertions. Of greater interest is their view on the professional conundrum posited, and for this reason, while the methodological approach contained within Discourse Analysis is acknowledged as a strong influence in the analysis undertaken here, and much of the information presented and analysed later in this section may be seen as consistent with Discourse Analysis, the arguably more flexible methodological approach of Thematic Analysis (Braun and Clarke, 2006) is the selected option for this collected interview data.

- **Thematic analysis** is also a method for identifying, analysing and reporting patterns within data. This method can be seen as poorly branded and is often not explicitly claimed as the method of analysis used by students, when in fact much discourse and content analysis is essentially thematic (Braun and Clarke, 2006). Thematic analysis differs from discourse, content and other methods of analysis discussed above. IPA, grounded theory, discourse and content analysis may all be seen as theoretically bounded – they are underpinned by an ontology and epistemology. The researcher's position is not wholly aligned with the ontological and epistemological contexts of these theories, and thematic analysis may be seen as unshackled in the same way. It may therefore incorporate the researcher's pragmatic approach well. If the research is not going to sit well with the (arguably) greater depth of these alternative methods of qualitative data analysis, it should not pretend to use them in their 'reduced' versions for the sake of appearing more technically complex than is necessary. Braun & Clarke claim that thematic analysis does not require the same level of theoretical or technical knowledge that, for example, IPA or grounded theory require, and the researcher, in tailoring a methodological approach to suit the data, considers this useful. Swift, direct access to the data can be obtained with this method, without a reduction in quality.

3.13.2 Method of data analysis selected

Thematic analysis offers the flexibility that the pragmatic approach required to address the research question directly, without compromising the approach to incorporate the more rigid alternatives discussed above. The interview question set is tailored to bring issues to the fore that are directly relevant to the study focus – this is inconsistent with the inductive method, which would analyse data not specifically alluded to by the researcher's questions. The researcher has extracted individual, specific instances of variability that are given as evidence by the interviewees and play out across the data corpus. These extracts are used verbatim for analysis, in order to identify some generalised themes and reach some tentative conclusions. As many themes as is practicable are then tested in the second, site-based strand of research here. This type of approach may be seen as semantic, rather than latent (Braun and Clarke, 2006). This is because the research is looking at explicit surface meanings initially, and then importantly, exploring and interpreting these responses, asking why they may have been given. A latent analysis might look more carefully at the ideologies and concepts that underpin the responses: while the interviewees mindset and the motives that lie behind some responses are considered carefully here, overall it would not benefit the research to conduct analysis of this nature, in the researcher's opinion.

3.13.3 Test EPC data analysis

For the second phase of research – the EPCs, two key high-level approaches were considered for data analysis, as follows:

- Descriptive analysis. Descriptive data analysis is used to describe or sumarrise data in a meaningful way, such that patterns or themes may be clearly identified and discussed. This approach might involve presenting a range of data with a mean, median or mode for a benchmark, or provide percentages, frequencies, or ranges in table or chart format, for ease of reference and discussion. This type of approach produces absolute numbers.
- Inferential analysis is more complex than descriptive analysis and may be useful in analysing the relationships between multiple variables, in order to present easily accessible results of complex numbers. Typically, inferential analyses may take the form of extrapolation: 'expanding' a sample taken for study to represent a wider group or all groups. This could in theory form a useful extension to this

study remit, whereby the comparatively small amount of data collected could be extrapolated to reflect variation of an entire region's EPCs, or even all EPCs across the country. Other uses of inferential analysis may take the form of correlation; describing the relationship between two variables, or regression; showing or predicting the relationship between two variables, or analysis of variance which may test the extent to which two or more groups differ from one another.

13.3.4 Method of EPC data analysis selected

The data collected and presented in Chapters 5 and 6 is given quite simply to mark the variation from one EPC to another, and then drill down into variation between a number of dwelling components recorded first by a control, then contrasted against this control with the results of twenty EPCs, at two test dwellings. While a considerable amount of data has been collected to enable this, the need for inferential analysis in order to present meaningful results within this study remit is not considered necessary, and descriptive analysis was therefore considered a satisfactory approach to the study. Inferential analysis may be used effectively on the data collected here for all manner of further research, such as, for example, to study the effect of individual errors where all other EPC inputs remain the same, or to extrapolate results to reflect all house types of a particular nature across the country, or all regions, or even all of the UK, (albeit with some carefully hedged standard error) but while these may constitute interesting further research, they lie beyond the remit outlined here.

3.14 DATA VALIDATION

Moskal and Leydens (2002) define validation as '*the degree to which the evidence supports that the interpretations of the data are correct and the manner in which interpretations used are appropriate'*.

Creswell identifies several threats to validation: internal threats, external threats, statistical conclusions threats, and construct validity threats (Creswell, 2003).

- Internal threats may come about as a result of changing a methodological procedure during the case study, using inappropriate or inadequate procedures for the study topic, or changing participants part way through a study.
- External validity threats arise when the researcher draws inferences from the data that are not supported by it, or inferences that would not be drawn by another researcher looking at the same data.
- Statistical conclusions validity threats arise when a researcher draws inferences from the data that are incorrect, not because of a misunderstanding or misrepresentation of the data, but because of inaccuracies in the models used in the research, and
- Construct validity threats arise when researchers do not define parameters or controls appropriately, and measure variation inaccurately as a result.

Quantitative data validation will depend on the study topic, though five methods are often cited for use dependent on the material. These are:

- Experiment review,
- Data triangulation,
- Participant feedback,
- Regression analysis,
- Statistical analysis.

During both phases of the study, the researcher took great care to avoid internal and external threats by preparing the methodological approach long before any interview material or site-based data was collected. During the data collection phases, data was monitored and analysed frequently, with preliminary results presented and scrutinised firstly in a hypothetical paper published in 2016 (Gledhill et al., 2016), then at Interim Assessment stage, Internal Evaluation stage, and also periodically through regular meetings with the researcher's supervisor up until the point of final submission. Statistical and construct threats may well be a consideration for the designers of the RdSAP model, (and indeed there is literature discussed in Chapter 2 that would support this) but this model is third party created and in widespread, national use: it is not a part of the research. While the interviews themselves may be considered a form of participant feedback and revisiting the subject matter informally with some participants since their involvement has helped with this, periodic experimental reviews were undertaken by the researcher both during the data collection process and during analysis which may add weight to the robustness of the data presented. In summary, the researcher has validated the study findings in the following ways:

- Presentation and cross examination of findings at Interim Assessment stage, Internal Evaluation stage, and through supervision,
- Peer review via an academic paper published in 2016 (and a further drafted paper peer reviewed in 2018, though not yet put forward for publication),
- 'Negative case analysis' (Cresswell and Poth, 2018) – a 'devil's advocate' approach is taken to the data by the researcher in order to form a thorough analysis of its content,
- Informal participant feedback, and
- Experiment review: the researcher will reflexively address biases that may affect the approach to, and interpretation of the study material, and arguably most importantly
- Triangulation: comparing and contrasting phase 1 and phase 2 data to check for consistencies, and inconsistencies both in the data itself, and in the researcher's interpretation of the data. This process – consistent with the pragmatic approach and mixed methods ethos – will ultimately help to form more refined and robust conclusions.

3.15 RESEARCH TIMELINE

Creswell and Plano Clark (2011) created a four-step flow chart for the exploratory design, which was a useful guide when refining the research proposal and aiding implementation. The first step fits quite comfortably with this study, and in testing its suitability for purpose, Table 8 is populated below with a bullet list of tasks that were fulfilled in order to implement this research.

Table 8: Cresswell and Plano Clark's Flowchart of the Basic Procedures in Implementing an Exploratory Design, populated with the key stages of this research. Source: Creswell and Plano Clark, 2011.

Step 1, Strand 1.	Design and implement the qualitative strand
Qualitative study.	Establish the qualitative research question: is there variability in UK domestic energy assessments, and if so, what causes this? Establish the qualitative research method: semi structured interviews of qualified DEAs Design interview question set that will most effectively address the research question: See Appendix C Obtain permissions: See Appendix B1 Identify sample: See Chapter 4. Collect interview data: undertaken in two phases, during 10^{th} – 26^{th} May 2016 x10 interviews, and during 3^{rd} – 29^{th} January 2017 x 10 interviews. See Section 4.2. Interview transcripts are available also. Analyse the interview data, triangulate with earlier research where possible, draw conclusions and identify themes that will feed into research strand two
Step 2, Preparation for Strand 2.	Use strategies to build on the qualitative results
Refine quantitative research question based upon the qualitative study undertaken in Step 1.	Thematic analysis of qualitative results of Stand 1. Draft a journal paper containing discussion and analysis of this strand of research. Categorisation and prioritisation of issues identified by interview respondents, in order to refine Strand 2 focus
Step 3, Strand 2.	Design and implement the quantitative strand
Quantitative study.	Establish the quantitative research question: strand 1 anecdotally confirms variability in UK domestic energy assessments, and points to potential reasons and causes for this. Strand 2 will focus on the matters discussed by interview respondents where practicable, as well as maintaining balance by giving attention to those matters which may disprove any developing theory.

	Establish the quantitative research method: the EPC process should be analysed in as authentic a manner possible within research boundaries. Design the site survey procedure that will most effectively address the research question: See Appendix D Limitations to be identified and discussed. Obtain permissions: See Appendix B2 Identify sample: See Chapters 4 and 5. Collect site survey data: undertaken in two phases: phase 1 completed during period 4th January 2018 – 30th March 2018. Phase 2 undertaken during period 3rd January – 30th May 2019. EPCs, EPC inputs and EPC xml data are available. Summer/Autumn 2019, analyse the site EPC data, triangulate with earlier literature where possible, draw early conclusions and identify themes that may be presented with the connected results for final thesis.
Step 4, Strand 2.	Interpret the connected results
Synthesis of qualitative and quantitative connections.	Spring/Summer 2020 leading up to thesis submission and viva, anticipated early 2021

3.16 LIMITATIONS

As the process highlighted in Table 7 above unfolded, some limitations were recognised and are acknowledged as follows:

- The site-based study was originally planned to encompass only the one dwelling, but the dwelling chosen had a number of unique attributes which all of the first ten DEAs selected for the site-based study remarked upon as being challenging to address. After seeing a pattern emerge and becoming aware of the limitations that would arise from completing all twenty proposed EPCs at the same property, this phase of research was aborted after ten EPCs, when a short reprieve for review of the collected data had been arranged anyway. Locating an alternative property with attributes that may complement those of property 1 did cause an unexpected delay but served to address variability over a greater range of dwelling attributes than may have been achieved at one property.

- A general consensus among proponents of the exploratory sequential design method is that any field work relating to the quantitative research strand should be conducted using subjects that were not involved in the qualitative study (Cresswell and Plano Clark, 2011). However, during this study the potential to triangulate interview material with site-based data was seen as an opportunity that could add value, and so where possible, the same participants used to take part in the interviews were used to produce the site based EPCs. However, with a requirement to alter the property type, and with limited study resources, it was not possible to commission 20 EPCs (one for each interviewee) on each property. Of the 20 DEAs interviewed, all were invited back to complete a site-based EPC, but the property they produced an EPC for will not be the same. Matching DEA with property is random, and based unintentionally on a ‘first come, first served’ basis. This is a limitation that must be acknowledged. Other limitations, including those related to sample size, participant selection and participant competence are discussed within the following chapters.

Two further limitations; that of the Hawthorne effect and the potential for confirmation bias are discussed in Section 3.18, where the researcher’s position and effect on the research are discussed.

3.17 ETHICS

Ethical issues arise during each stage of the study process, and it is vital to both acknowledge these as they arise, and tackle them appropriately, especially where people are in the process. Three key ethical milestones exist so far as the University of Salford are concerned: their Ethical Approval Panel request plans for the study at its inception, at any case study stages, and at Internal Evaluation stage. In addition, should any changes to the study methodology be made that would have an ethical impact, further approvals should be sought as required. The researcher has gained all necessary approvals, which are contained in Appendix C of this thesis. These outline the potential for harm to participants (both psychological and physical) as well as any potential social, legal, or economic vulnerabilities. The researcher also obtained consent from each participant after submitting consent forms to them, along with participant information sheets. These too can be found in Appendix C.

It is also important to consider the ethical impact on the data itself. The use of thematic analysis, for example, can leave data vulnerable to presentational misuse by the author: key information can be omitted in the interest of supporting an existing hypothesis that may have been, after analysis, found not to hold water. While this is a risk that cannot be wholly eliminated, the author used, at times, relatively long quotes, verbatim, to help address this, and the consistency with which the same themes emerged may arguably have reached a saturation point worthy of their status as selected extracts. Additional, fully transcribed responses are retained by the researcher for validation purposes, should they be needed, and limitations are recorded by the researcher both in the text here and in journal notes.

In showing that all necessary and suggested ethical protocols have been met by the researcher, the table below records the actions taken throughout the study process.

Table 9. Ethical issues in qualitative, quantitative and mixed methods research, adapted from Cresswell & Poth, 2018.

Ethical Issues throughout the Research Process	Types of Ethical Issue	How the issue has been addressed
Prior to conducting the study	• Obtain the necessary approval from the University's Ethical Approval Panel • Negotiate authorship for publication	• Consult the necessary ethics codes • Submit the approval documentation in the appropriate format • Obtain approval (see Appendices C, D & E) • Give credit for research and agree author order
Beginning the study	• Make checks to ensure there are no confidential,	• Make appropriate checks to ensure there are no confidentiality issues,

	privacy related, commercial or economic ethical conflicts • Inform case study participants of the research aim and objectives • Obtain consent for participation in the research using the appropriate University template	nor commercial, privacy related or economic conflicts by discussion with participant's managers and company directors before approaching participants • Explain the purpose of the study to participants at the beginning of each interview, ensure they have understood the way data will be used, and transcribe their verbal consent • Obtain participants' written consent prior to commencing
Collecting data	• Respect confidentiality, privacy & a need for anonymity • Ensure all participants are given the appropriate respect, and treated equally • Do not lead participants during interviews or during site based study exercise • Do not use participants by presenting 'mistakes' or erroneous data or information	• Remove or redact private or sensitive information from the data at the collection phase • All interview and EPC data is anonymised • Confidential or commercially sensitive data was taken during the interview phase, and this is not transcribed, or referenced in the text. Other inappropriate interview material is also redacted • Explain the purpose of the study prior to each interview. Explain that at any time the participant can withdraw and their data will not be kept or used in the study. Pay a reasonable fee for their time where a commercial service is offered (EPCs, during study phase 2) • Use exactly the same question set for each interview, without leading or interrupting the participants midway through their responses

Analysing data	• Avoid confirmation bias • Use appropriate and robust methodological approaches • Validate data • Confidentiality, privacy & anonymity: remove or redact sensitive, personal and corporate information from the data	• Conflicting data, and data that contradicts the study hypothesis is presented and discussed • This methodological section outlines the approach adopted and the reasons for this. Alternatives are analysed and discussed also • Transcripts and EPC data are checked for accuracy and triangulated for consistency. Outliers and inconsistencies are noted and recorded in the body of this thesis. Limitations are recorded where applicable • All interview and EPC data is anonymised • All sensitive data remains confidential
Reporting, sharing and storing data	• Ensure all data is filtered for confidential, commercially sensitive or otherwise harmful information, either to the participants themselves or to companies or associations to which they are affiliated • Avoid presenting only that information which confirms the study hypothesis • Avoid falsifying information • Confidentiality: consider data protection when using and storing data	• All interview and EPC data is anonymised at the data collection and analysis stages • Commercially sensitive data was taken during the interview phase, and this is redacted or removed prior to any reporting. Other inappropriate interview material is also redacted • Conflicting data, and data that contradicts the study hypothesis is presented and discussed • Report honestly and candidly • The researcher will honour the offer made to provide copies of the thesis and any publications which reference it to participants

	• Do not duplicate publications or plagiarise work	• Adhere to GDPR when storing data. Redact or remove personal and commercial references • Be honest about the data obtained and the way it is presented. Give credit where it is due.

3.18 RESEARCHER REFLECTION & SUMMARY

This research methodology has been drafted by a practitioner immersed in the operational world of energy assessments for residential buildings, primarily for existing housing stock. The researcher has held the requisite qualifications to produce EPCs for both new and ‘second hand’ buildings; the latter soon after the inception of the EPC. The researcher himself has produced EPCs for all of their current uses, and has managed teams of DEAs of varying sizes when producing them, for a variety of different projects. This has given the researcher a unique insight into the production and outputs of EPCs, including the behaviours of some DEAs, and the effects inaccuracies can have in a range of different contexts. A journal paper published at the early stages of this research explores the hypothesis of EPC variability, and during this research, each of the research participants were aware of the researcher’s hypothesis, and some had sight of the journal paper (Gledhill et al., 2016). This brings about two important potential effects on the research outcomes that may be perceived as limitations; that of confirmation bias when carrying out the case studies and analysing the data, and of a Hawthorne effect from the participants during the case studies. It is vital that the researcher acknowledges these potential limitations and mitigates against them where possible, and in addition to the measures noted earlier in this chapter, the case study chapters (4 and 5) also describe steps taken to guard against these potential limitations.

The aim of this section has been to establish the author’s ontological and epistemological position, and clarify the methods and methodological approaches adopted, analysing the options available to the researcher and providing justification for the selections made.
The chapter has unfolded by first defining research, and then:

- Exploring research paradigms, and philosophical assumptions, and settling on an abductive approach to the research question, which may combine inductive and deductive methods.

- A pragmatic theory is considered best suited to the research question, which can include both positivist and interpretivist approaches.

- A mixed methods research design is justified, because both qualitative and quantitative data must be collected if the research question is to be addressed effectively.

- The exploratory sequential design, also referred to as the instrument development design, and the quantitative follow-up design (Creswell et al., 2004, Cresswell, 2009, Morgan, 1998) is justified and adopted.

The chapter has discussed options and justifies a data collection strategy, a data validation strategy, and outlines a timeline, limitations, and ethical considerations for the research. This sets the foundations for the researcher to proceed to the case study research in the next chapter, which will focus on the first of the two stranded approach identified here: the qualitative study, consisting of interviews with practicing DEAs.

CHAPTER 4 THE QUALITATIVE DEA INTERVIEWS

4.1 INTRODUCTION

This chapter will focus on the first, qualitative strand of study. The chapter will expand upon the justification for this strand, as discussed earlier, and will elaborate upon the methodological approach given in Chapter 3 by discussing the specifics of the strand: the preparation, and implementation of this first strand of study, as well as the limitations specifically associated with this strand. After this, the main body of the chapter will present the results of the research undertaken at strand 1, and summarise with some discussion about the implications of these results as a standalone exercise. The chapter will end with analysis of the results, specifically in relation to how they might feed into phase 2 of the research and contribute to the study aim and objectives.

After having established in Chapter 3 that personal interviews with practicing DEAs were the most appropriate way forward, a semi-structured interview schedule was prepared. Morgan (1998), noted that the semi-structured interview gave the opportunity not just to relay what is undertaken (during the process of gathering the EPC data in this case), but also to look at the contradictions and complexities as to how things work in practice. The interview question set was designed with the intention of gleaning information about how the EPC surveying process works in practice, and whether this might contribute to inaccuracies. The questions were ethically approved by the University prior to embarking upon the interviews themselves. The interview was designed with an end-hypothesis in mind: that the results of EPCs are variable and can be unreliable, consistent with the hypothetical study undertaken by Gledhill et al., (2016) discussed in the literature review in Chapter 2 of this research. However, the interview itself was designed to focus on the surveying *process*, as opposed to the survey results, and to this end, no pre-formed hypothesis had been made. While it could be said that some research bias is inherent in the hypothesis formed about EPC outcomes, the question set was carefully designed to ensure DEAs were not encouraged to give any particular response, and all questions gave DEAs the freedom to respond with their own unguided opinion. DEAs were not prompted mid-question, and after questions were asked, each DEA was left to reply without interruption. Each interview was recorded, and these recordings were later transcribed verbatim. All the respondents, including the organisations for whom they worked, were assured of anonymity. A copy of the University's ethical approval documentation is included in Appendix B, and while only selected extracts from transcriptions are included here, each full transcription has been retained by the researcher in case it is called upon at a later stage.

4.1.1 Interview Respondents

The sample frame used to identify the DEAs was that of a catalogue of employees and self-employed consultants used by insulation installers and housing associations to produce EPCs as part of their respective compliance processes, under the government's Energy Company Obligation (ECO) scheme, or Right to Buy scheme. Each of the DEAs who took part in the study did not only do this type of work, but instead had experience of producing EPCs for a variety of different purposes. They were located this way because the researcher had been employed as an independent third party in the capacity of monitoring the ECO compliance process, and in a similar role as a consultant for housing associations, providing valuations under the Right to Buy. As such, with relative ease, EPCs produced during these processes could be located. As a part of these processes, the researcher had had contact in a professional capacity with most of the DEAs selected for interview on an ad-hoc basis, though no study-related scrutiny of the DEA's work had taken place prior to inviting them for interview. A DEA's contact details are published on each completed EPC, and DEAs were initially contacted using this method. DEA individuals numbered over 100 in total. After the University's ethical approval process was completed, a randomly selected sample of 46 of these DEAs were approached, initially by email or by telephone, and the nature of the study was discussed. Of these, 20 agreed to take part in the semi structured interview, although interviews took place in two batches of ten, approximately six months apart. This was so the process could be broken into manageable chunks primarily, although this gave the opportunity to look at preliminary data after the initial ten, and the second batch of ten also added reliability to the initial sample in order that a more robust outcome could be achieved, including some saturation of key responses. Each of the DEAs interviewed were producing EPCs on a full time basis for both sale and rental, and a variety of grant funded or subsidised schemes, such as the ECO, as their primary source of income at the time the interviews took place.

The sample size of 20 is limited, and when drawing conclusions from a small sample it must be acknowledged that the opinions expressed are not necessarily representative of the profession as a whole, and that results found here may not be wholly consistent with those that may be obtained if a much larger sample, or indeed all qualified DEAs were interviewed. The thoughts of these DEAs, who produce EPCs for both sale and rental as well as other schemes such as ECO may vary from those who produce EPCs purely for a single purpose, such as sale and rental of residential property. However even with this small sample, theoretical saturation was identified in many key aspects, and this may be considered compelling. The specifics are discussed later in this chapter.

4.1.2 Interview Schedule

Interviews were undertaken in two phases, with ten interviews undertaken over the period April – May 2016, and a further ten interviews undertaken a litte over six months later, during period January – February 2017. The interview itself contained 9 questions in total. These were as follows:

1. *What is your professional background?*

2. *How long have you held your DEA qualification for, and how many EPCs would you estimate you have produced in total?*

3. *What are your thoughts about the EPC process?*

4. *What do you find are biggest issues in getting a full appraisal of the property, when carrying out an EPC?*

5. *Do you think EPCs are variable between Assessors?*

a. (If yes) What do you feel the main causes of the variations are?
b. (If no) What are the main reasons for the consistency?

6. *What do you think are the key variables that would have an influence on the results of an EPC?*

7. Do you think that the outcome of an EPC produced for sale or rental would be the same as that produced for a different purpose, for example under the government's Energy Company Obligation (ECO), or the Feed in Tariff (FiT)?

8. What improvements would you make to the EPC process?

9. Is there anything you'd like to add to this before we end the interview?

The interview question set is also recorded in Appendix C of this thesis. In Table 10 below, the interview question set is linked succinctly to the literature.

Table 10. Table linking the literature to the interview questions.

Question	Link to literature
1.	Andolorro et al. (2010) discusses the prerequisite of some EU countries to have a linked professional background to qualify as a DEA. Imam, Coley & Walker. (2017) compare the results of experienced, and inexperienced energy assessors.
2.	The Zero Carbon Hub, (2013) queries the skills, understanding, knowledge, competence and experience of energy assessors. Imam, Coley & Walker also discuss the experience and competence of energy assessors.
3.	Tsang & Antony, (2001) look at procedures as part of a wider discussion about total quality management (TQM). The function of auditing bodies (Elnhurst, 2014) in monitoring the EPC process is called into question (Gledhill et al., 2016)
4.	This is linked to the default assumptions that are applied by the RdSAP model when a full appraisal cannot be carried out. Gledhill et al., (2016) discuss this, as do Gonzales-Caceres & Vic, (2019), Hardy & Glew, (2019) and Ahern & Norton (2020)
5.	Jenkins, Simpson & Peacock (2017) research EPC variability in their 'mystery shopper' study of Green Deal EPCs. Gledhill et al., (2016) hypothesises about EPC variability, Kempton (2001) discussees surveyor

	variability, and the EHS, MHCLG, NEED & HEED all publish EPC data, draw conclusions from it, and formulate policy based on the data.
6.	Stone et al. (2014), and Palmer & Cooper, (2013) both study the dwelling components which have the greatest impact on EPC variability. Also Gledhill et al., (2016) carried out a hyothetical study into EPC variation.
7.	There has not yet been literature focused on the potential conflicts of interest of DEAs which the researcher perceives as a gap in existing knowledge, but Duxbury (2013) questions the 'carbon trading' based on EPC contents under the Energy Company Obligation scheme, conflicts of interest are discussed by the researcher, with use of hypothetical scenarios.
8.	Booth et al., (2012), Fan & Xia, (2018), Jenkins et al., (2017) and Gledhill et al., (2016) all recommend improvements to the EPC process, but there has not yet been literature seeking the opinion of practising DEAs on the matter.
9.	This question was deemed good practice for the semi-structured approach.

4.1.3 Analysis

With the research aims established, and the questions for this strand of research decided upon, the next stage would be to adopt the methodological approach discussed in Chapter 3 that would best suit these aims and questions, in order to get the most from them, in as rigorous as possible a way. Most questions invited open ended responses, which would look to obtain the opinions of DEAs. As can be seen from section 4.1.2 above, it is important to stress that these questions were not designed to test the DEA's technical knowledge, but rather their own personal experiences, opinions and views. The extent to which DEAs understand what underpins the EPC exercise is however broached by a number of DEAs during the interviews.

A number of methodological approaches were considered at this stage, and these are discussed in some detail in Chapter 3. After careful consideration, thematic analysis was selected as the most effective approach to the study material here. In taking this approach, the researcher has extracted individual, specific instances of discussion about variability that are given as evidence by the interviewees and play out across the data corpus. These extracts are used verbatim for analysis, in order to reach some generalised conclusions, and so far as is practicable these are then tested in the second, site-based strand of research that follows. This type of thematic analysis approach may be seen as semantic, rather than latent (Braun amd Clarke, 2006). This is because the research is looking at explicit surface meanings initially, and then importantly, exploring and interpreting these responses, asking why they may have been given. A latent analysis might look more carefully at the ideologies and concepts that underpin the responses: while the interviewees mindset and the motives that lie behind some responses are considered carefully here, overall, it would not benefit the research to conduct analysis of this nature, in the researcher's opinion.

To summarise this section, a decision to use thematic analysis was taken based on a review of the alternatives in Chapter 3. The designed question set and the researcher's anticipation of the feedback that might be given, led to the procedural approach of transcribing all of the material from recordings, and identifying patterns from the interview transcripts, coding these on a 'per question, and per interviewee' basis initially, then bringing the data corpus together for cross referencing during the finalising of the analysis process.

Next, pertinent themes are extracted and reviewed in the results section below. Following this, these themes and patterns are brought together where they are synthesised and analysed in the discussion section at the end of this chapter.

4.2 RESULTS

4.2.1 Characteristics of respondents

Table 9 below shows the professional and academic experience of the sample set of respondents taking part in the strand 1 study. Its contents, and the respondant's backgrounds more generally are discussed in this section.

Table 11. Showing professional and academic experience of sample set of respondents taking part in the strand 1 study.

DEA	Background	Academic qualifications	Professional qualifications	Years' experience
1	Building/Construction	Relevant Degree	Qualified DEA	> 15 years related
2	Insulation/Energy Surveying	Relevant HNC level	Qualified DEA	> 10 years related
3	Professional not-related	No relevent FE/HE	Qualified DEA/MNAEA	> 10 years related
4	Building/Construction	Relevant HND level	Qualified DEA	> 10 years related
5	Insulation/Energy Surveying	No relevent FE/HE	Qualified DEA/OCDEA	> 15 years related
6	Insulation/Energy Surveying	No relevent FE/HE	Qualified DEA	> 15 years related
7	Property Letting/Management	Relevant Degree	Qualified DEA	> 10 years related
8	Professional not-related	No relevent FE/HE	Qualified DEA	> 10 years related
9	Building Surveying	Relevant Masters	Qualified DEA	> 20 years related
10	Insulation/Construction	No relevent FE/HE	Qualified DEA	> 20 years related
11	Architectural technician	Relevant HND level	Qualified DEA	> 20 years related
12	Architectural technician	Relevant HND level	Qualified DEA	> 10 years related
13	Housing Management	No relevent FE/HE	Qualified DEA	> 5 years related
14	Housing Management	Relevant Masters	Qualified DEA	> 5 years related
15	Building Surveying	Relevant Degree	Qualified DEA/MRICS	> 15 years related
16	Professional not-related	No relevent FE/HE	Qualified DEA	> 5 years related
17	Conveyancing/Energy surveying	No relevent FE/HE	Qualified DEA/OCDEA	> 15 years related
18	Housing Management	No relevent FE/HE	Qualified DEA	> 10 years related
19	Housing Management	No relevent FE/HE	Qualified DEA	>10 years related
20	Housing Management	Currently in related FE	Qualified DEA	> 5 years related

17 of the 20 respondents were male, and all were of varying ages. They obtained their qualifications between 2008 and 2017 and had completed a total number of EPCs of between 50 and 5000, each. There was no correlation between the period that the qualification was held and the number of EPCs produced. Interviews were undertaken in two ‘batches’ of ten. Of the first ten interviewed, half had no related further or higher education qualifications, and the other five respondents had between them an HNC, HND, two had degrees and one a master’s degree. Of the second batch of ten DEAs, interviewed approximately six months later, six had no higher or further education qualifications. Two of the remaining four had HNDs, one a relevant degree, and one a relevant master’s degree. The academic qualifications had no discernible impact upon DEA responses to interview questions. Eighteen of the twenty DEAs interviewed had work experience that may be considered related to the DEA qualification prior to becoming a DEA. The two that had qualified as DEAs without any related experience had no further or higher education qualifications but had been producing EPCs for over five years: one for ten years. Work experience could be said to be loosely linked to the DEA qualification in 18 of the 20 interviewees’ cases, although few might be said to have directly related work experience. This is subjective, and while each of these 18 interviewees could claim to have construction industry related experience, for the purpose of the table recorded below, ‘related’ experience is recorded on the basis of the

feedback given from the DEAs themselves. To be more specific, experience included surveying Local Authority housing stock for maintenance liabilities, surveying houses for loft and cavity insulation measures, residential valuation, autoCAD operation (connected with residential property), land surveying, and technical monitoring of insulation installations. All DEAs had experience of producing EPCs for their originally intended function, for sale or rental of residential property, as well as for subsidised or fully funded heating, renewable or insulation installation schemes. It should be noted as a limitation that no DEAs were interviewed with under five years' experience. Respondents were chosen at random, though from a bank of DEAs that were recruited into their roles in most instances because they had previous experience. This may simply be attributed to the researcher's professional position at the time, which happened to be linked to roles where experienced DEAs were needed. An even spread of qualifications and experience was not artificially factored into the selection criteria, as this was thought to bring up the possibility of selection bias: the researcher considered it good practice to have as little possible interference with the selected candidates. DEAs with fewer than five years' experience, as well as those who produce EPCs for only one specific purpose may have had a different perspective.

4.2.2 The EPC process and appraising a property

Eight respondents described the EPC process using words including 'simple', 'straightforward', 'generic' 'clear', 'unambiguous' and 'realistic'. The consensus among all respondents was that the EPC process was manageable. However, for one respondent, this came with a caveat:

DEA 1 'It's a straightforward process, but understanding the conventions is the difficulty. People don't understand the conventions and go about it in different ways'.

Other DEAs also acknowledged the perceived simplicity, but did not necessarily see it as a good thing:

DEA 2 'It's simple, it's open to persuasion by the DEA to sway the results of the EPC, so the EPC is as good as the DEA who's doing it'.

This was the first time a respondent mentioned the possibility of deliberate manipulation of data at this early stage in the interview, but the theme develops with other DEAs as the interview unfolds and is discussed in more detail later in this chapter. This was also considered an appropriate time to bring up the lack of a need for any previous building or construction related experience by DEA 1, who commented that:

'There's no prerequisite to become a DEA, anybody can become a DEA within five days, and that's a problem'. DEA 1.

This rather contradicts the assertion made by Andaloro (Andaloro et al., 2010) discussed in Chapter 2 of this thesis, where a high confidence rating is given to DEAs in the UK based on the training given. DEA 1 was among the most experienced of the group selected for interview and expressed concerns on a number of occasions throughout the interview about the speed at which DEAs in the UK can become qualified, as well as the lack of any previous experience needed to get on to a DEA training course. He also expressed concerns about the training given, questioning its fitness for purpose. This could be construed as a professional concerned about the devaluation of his skills and the consequent effect this may have on his earning potential, but with the consequences of EPC inaccuracies having greater implications now than ever before, it may also be considered a valuable point.

Another theme that emerged here was in connection with the amount of control DEAs had over EPC outcomes, with concerns that the assumptions being made on their behalf by the RdSAP model were not always as accurate as they could be, and that this could lead to a misleading EPC. The non-intrusive nature of the EPC process was brought up on three occasions as a shortcoming of the process which led to the need for some assumptions.

'A lot of the EPC is assumed, because its not an intrusive survey, and I think that could lead to a lot of different outcomes'. DEA 4

Two DEAs go on to explain in more detail what concerns them about the nature of assumptions, relative to access and the non-intrusive nature of the EPC process:

Insulation, particularly things like room in roofs, isn't really satisfactorily addressed because the DEA doesn't have a mandate to open hatches that are screwed down, but without that you cannot really accurately detail what the actual efficiency of the property is'. DEA 8

'For example I was in a property last week and the property owner had put under-floor insulation in the property and asked if I could include it, but I said no you can't because I can't see it and there's no paperwork for it. I have to put unknown, and once I'd done this the recommendation didn't come up so that was ok, but the EPC was three points lower than it would have been'. DEA 9

In respect of obtaining a full appraisal of the property in order to collect all the data required to produce an EPC, all DEAs mentioned the practicalities of obtaining access to various parts of a property as an issue that may not always be appreciated in theory. In addition to this, the householders themselves were criticised in some cases, as being a barrier to the careful and methodical collection of data.

'Physical access. Lofts are difficult to access, and personal effects are often in the way'. DEA 3

4.2.3 The variability of EPCs

The responses that were given to these questions may be considered startlingly frank in many cases. The initial question was 'Do you think that EPCs are variable between Assessors?'. All twenty respondents answered to the affirmative. The question was designed to attract a direct response, and it did so. Short answers included: *'Hugely.'* DEA 3, *'Yes, definitely.'* DEA 2, and *'Definitely.'* DEA 4.

The follow-up question to this provoked the need for some elaboration, and nineteen out of the twenty respondants obliged, some with material that could be categorised as 'human error'. Respondents pointed to a range of issues that would lead to variability, including heating and insulation provision within a property, but measurement was noted as being a primary source of variation by most DEAs.

'Yes, if I went to do an EPC and another surveyor did, I'll bet that the two results will be different. Things like dimensions and how you split up the property, doing heat loss perimeters and things like that'. DEA 7

These comments regarding dimensions have proved useful when tailoring the site-based Strand 2 study, and the processing of the site based EPC's results at Strand 2 has been tailored accordingly.

A point made regarding the effect of secondary heating systems on the overall EPC score is also noted within a study by Gledhill discussed earlier in this research (Gledhill et al., 2016):

'...focal point fires, those tend to drop it by as much as five points, and if people miss them for me it's a big variable. You have to reflect, and make sure its correct'. DEA 9

Gledhill also makes a point in his paper about interpretation and experience, and the same assertion is made by a number of DEAs, including DEA 6:

'It's interpretation of what you're looking at, one individual may look at two drill holes in a wall and say it has cavity wall insulation, the other might say well hang on, there should be over one hundred drill holes to denote cavity insulation. It's down to the experience of the individual'. DEA 6

DEA 2 points to the inconsistent approach the DEAs may sometimes take and touches on the misrepresentation that is discussed in the next section. He suggests that there are inconsistencies based around the purpose for which the EPC is commissioned:

'I think these are being done with different objectives. For sale or marketing of a property….the benefit is for it to be a higher score and make it look a more ecomonical place to live, whereas those for the carbon scoring for energy efficiency measures it's the opposite and you want to show there is an improvement to be made so the lower the score the bigger the improvement of the energy efficiency measure…. And yes, I think that has a massive effect on the overall methodology people are using and the score that results. DEA 2

4.2.4 The deliberate misrepresentation of EPCs

Much of the respondent's material above might, as mentioned earlier, be put down to human error, or a lack of experience, and with respect to the latter, the quality and scope of the DEA training course is discussed later in this chapter. Human error of this nature might be anticipated, although there may be ways of minimising this and/or mitigating against it which are discussed in the conclusions of this thesis and may be considered grounds for further research. However, sixteen of the twenty respondents made comments relating to the wilfull manipulation of data that could be considered cause for concern and may be said to fall into a category of 'deliberately misrepresented EPC data'.

'EPCs for sale and rental market are quite straightforward but those are manipulated sometimes to make a property more attractive by the estate agent and the EPC isn't as accurate as it should be'. DEA 3

Also, in respect of the production of EPCs for the purpose of obtaining funding towards the installation of insulation measures, DEA 1, along with all the DEAs made the assertion that EPCs are being willfully manipulated in some cases:

'I think fraudlent EPCs, where people are getting paid for ECO EPCs based on the lifetime scores for a boiler for example. The LCS (lifetime carbon savings) is dependent a lot on heat loss perimeter and area, so you see a lot of EPCs where the areas are inflated basically ... or they're saying they can't get access to a loft to see if there's any insulation, so it assumes none so this increases the LCS, so in one case I've just seen he said there was no access to the loft of either the main building or the extension, and I got access striaght away so there wasn't an issue so basically they just lied to inflate the LCS. I've noticed this happening, definitely'. DEA 1

Some DEAs pointed to personal experience of pressure from employers to manipulate EPC data. DEA 4 made the same general asssertion as DEA 1 above, regarding the manipulation of EPC data, and then proceeded to support this with some of his own experience:

'…as far as I know a lot of people are basically lying about metreage and stuff like that to basically make a lot more money … you can engineer the EPC to say what you want it to say. If you need a high carbon content out of the property, then you can manipulate the EPC. I actually stopped doing EPCs for a solar panel company because they wanted me to manipulate EPCs, and I wouldn't do it. They then sent it to another DEA who did manipulate it'. DEA 4

DEA 9 also wanted to support his assertions with personal experience of pressure from an employer, and this anecdote is consistent with the modelling exercise undertaken by Gledhill (Gledhill et al., 2016):

'you shouldn't be unduly influenced, but I can see why people would be pushed down a route to save as much carbon as they can. As an example, for a social landlord of mine there were quite a lot of people who had secondary heating which would bring down below the standard of their solar pv installs (the Feed in Tariff has a minimum EPC Band D requirement) *and they asked that I ignore these heaters, but I couldn't do this. DEA 9*

As with the respondent's comments in respect of human error in the earlier section, measurement is again the focus of the 'deliberately misrepresented' EPCs in the eyes of most of the ten interviewed DEAs, as mentioned by DEA 1 above, and this may be because the audit system operated by Accrediting Bodies can have particular problems in picking this up:

'The dimensions which is something that is very difficult to challenge (during an audit by the Accrediting Body) because when it's looked at and audited and checked its done from photographs. So, looking at it you can't necessarily say if its shorter or longer than its being presented, and you can't really check against that or prove against that without going on site and doing that which happens very rarely to my knowledge'. DEA 2

Like DEA 2 above, DEA 4 also made the point in his interview that the auditing process in its current form would not pick up some deliberately misrepresented EPC data, and that DEAs who are intent on doing this are aware of how to manipulate the system:

‘They make the audit fit what they’ve lodged rather than it being a true and accurate assessment of the property. I know people who keep a photograph (of various building elements) and they submit them as their evidence (for audit) as and when required’. DEA 4

One DEA, despite confirming he would like to take part, responded in such a way as to suggest he may have been concerned about the possibility that the information he gave could have implications for him personally. His response to the issue of variability was affirmative, but in following up as to why he thought EPCs were variable, his short reply was: *‘Outside influences, such as employers’. DEA 5.* No further information was given. Other respondents were more forthcoming with respect to pressure brought to bear, in their opinion, by employers:

‘Let’s say I’ve heard that certain companies insisted on DEAs stating that loft insulation is less than it should be, so they can get funding for it. There is pressure for DEAs, especially if they’re self employed, to actually lean toward what they’ve been told (to do) to get their money’. DEA 6

4.2.5 The assumptions of RdSAP

A part of the EPC surveying process is mentioned by a number of DEAs as being an issue, and this is the ability to be able to omit certain information, thus leaving the RdSAP model to default to an assumption, which in many cases may lower the SAP score, and represents a worst-case scenario. DEA 1 is concerned that DEAs have realised this, and are using the defaults to manipulate an outcome that better suits their requirements:

‘it (the RdSAP model) can allow for shortcuts to be taken so where possibly more information could have been available it may be in the DEA’s interest to not research all of that and take the extra step, to take the path of least resistance and to take a way that isn’t cheating and is within the rules but isn’t quite as accurate as it could be. How DEAs approach this is quite variable, which you don’t want that when you’re doing this really’. DEA 2

DEA 2 explains that he believes the RdSAP model provides less energy efficient default assumptions when information is not made available in order to incentivise DEAs to collect all the information they possibly could to enhance a property's SAP rating, because in the case of sale or rental, for which the EPC was originally intended, this would be likely to make the property appear a more attractive proposition. He saw this as ironic, that in his view these same 'worst-case' defaults are being abused to the benefit of DEAs who produce EPCs for a different purpose, to yield higher carbon savings scores when energy efficient measures are installed:

'The other thing is the idea of the EPC is … to always look to give it a lower score if possible (the RdSAP defaults), so if you're not sure whether the windows were pre or post 2002 if you can't find a date stamp you're (supposed, according to the Conventions) to say pre 2002 which will reduce the score and the effect that has is that if you're looking to lower the score to uplift the carbon savings, you're actually being encouraged to do that in a way by the Conventions or the rules of the EPC, so they were there (originally) to stop people enhancing scores (to make a property for sale or rental look more attractive) but now they're being used in the energy efficiency measure process its having the opposite effect really, people are using it to downgrade the score where possible'. DEA 2

Solutions to what is seen as the conundrum posed by RdSAP assumptions were put forward by two DEAs, who remarked in similar ways that an invasive inspection might be more appropriate. DEA 6 suggested that only a more intrusive inspection would yield sufficiently reliable data with which to produce all the information contained within the EPC:

'The downside of (RdSAP) EPCs is that its assuming too much. The on-construction EPCs don't assume anything, do they, but with RdSAP it's assuming too much. I think we should investigate things more. We're getting incorrect recommendations because it's not an intrusive survey'. DEA 6

DEA 8's comments were also partly consistent with this:

'I would mandate that DEAs are more investigative in their attempts to find insulation, because I think that it's a drawback at the moment'. DEA 8

4.2.6 The EPC auditing procedure

The remarks made by respondants in the latter sections of the interview revolved predominantly around two key areas: the first, mentioned by eight DEAs in some way during their interview was the need for a more robust auditing procedure from Accrediting Bodies. DEA 1 makes assertions both about the knowledge and understanding of the auditors themselves, and about the need, in his opinion, for on-site auditing:

I think the auditing process needs improving. A lot of it is done by people who haven't actually done EPCs (on site). I think they should actually visit site rather than review photos (from behind a desk). It's very easy to submit evidence to pass your audit. DEA 1

DEA 2 concurs and asserts that DEAs are taking advantage of the EPC audit system:
'The auditing process needs to be tightened up. Those people who are going and doing them dishonestly are the ones who know how to pass the audit without it being flagged up, and some way of monitoring these people and trying to weed out the people who are doing lots and lots of EPCs and making lots of money out of it but not necessarily doing them as they should. Seeing it from my point of view as a technical monitoring officer I see lots of this'. DEA 2

DEA 4 expresses concern that even after being caught manipulating EPC data, the auditing bodies appear to have insufficient capacity for the repremanding of DEAs:

'I think the audits should be more strict. So that some people who manipulate the EPCs for the own financial gain, even when they've been caught out by the accrediting bodies, they get a slap on the wrist and don't do it again, and another chance… well I think there shouldn't be another chance and if you get caught out blatently producing incorrect EPCs then you should be struck off and not allowed to produce them'. DEA 4

DECC (2016) have recently announced a new system of 'smart auditing', involving the flagging up of properties with apparent inconsistencies or irregularities for audit. While it may be reasonable to assert that this is an improvement on the current system, consistent with the thoughts of DEA 8 below, more thorough auditing of EPCs *on site* may be considered the most effective way of addressing some of the issues highlighted in this section of the dissertation.

'The auditing is moving a step in the right direction, because smart auditing would look at, say a 1900 property that has a cavity wall, because it might be wrong. This is better than random audits in my opinion'. DEA 8

DEA 8 goes on to suggest that at least some audits should be undertaken on site, however.

4.2.7 DEA training

A common theme mentioned by six DEAs was the need for more rigorous training. DEA 1 makes an assertion consistent with the notes of Andaloro (Andaloro, Salomone et al., 2010), recorded earlier in this dissertation, that only those with prior experience and a related professional qualification can become DEAs in Spain, Luxembourg and Greece. He concurs:

'I think there needs to be a prerequisite to becoming a DEA, or at least improve the training, the course itself. Training in five days to become a DEA with no background at all and be out there doing the same job as myself who's been doing it for years, well it's a little bit wrong, and they'll be getting them wrong'. DEA 1

Other DEAs also express concern about the speed at which a DEA with no previously related experience can qualify:

… 'there are too many DEAs out there that have been trained too quickly from a non-building background, so they don't understand the data they're collecting and they don't understand why they're producing the EPC, they're just putting in the data and letting it spit out the other end. I think it should be clamped down and a lot of re-training going

on. The accrediting bodies need to be brought up, they're allowing people to get away with manipulation and it shouldn't be allowed'. DEA 4

4.2.8 The value of EPCs

A final theme that emerged from multiple DEAs during interviews was that of the percieved value of EPCs, where five of the ten DEAs expressed an opinion. DEA 12's comments may be considered typical of the overall point they were making:

'I think people just see it as a piece of paper, for paper's sake you know what I mean, nobody really wants to have one done because they don't understand them or don't know how to utilitse them'. DEA 12

Banks (2008) touched on this with a study (the more detailed focus of which is contained in the literature review) that found a consensus of the opinion of those commissioning EPCs were that they constituted a 'stealth tax' and were not of great value in informing prospective purchasers about a property. This would bear out comments made in research by Watts (Watts et al., 2011), discussed in the literature review. Watts was able to point to the interview data of recipients of EPCs at their inception, where it was inferred that little consideration was given to the content of the EPC when making the wider judgement of whether to proceed with their purchase. Also linking closely with both the EPC's percieved value and the quality of training and staff, were comments from three DEAs related to the price paid for EPCs.

Oxera (2008) and Chahal, Swan et al., (2012) both mention a need for more precise costing of energy efficiency measures within their research, which is discussed within the literature review here. This might be considered pertinent with regard to the second half of the DEA 10's comments here, as it may be considered hard to know how to use a document that does not contain clear guidance on the cost of improvement works, or a more thorough explanation to the layman as to what these imrovement mean.

On the more literal value of the EPC, the following opinion from DEA 15 was typical of that noted by fourteen of the twenty DEAs:

'I would make it more professional. I think they could have more worth and that the prices charged for EPCs should be higher'. DEA 15

4.3 DISCUSSION

All the DEAs interviewed asserted that there was EPC variability. In addition to this, there was some consistency in their explanations as to why this variability comes about. Errors relating to simple tasks, such as measurement of dimensions and insulation depths were pointed to, with assertions made that DEA remuneration was poor, such that EPCs may be rushed, leading to simple errors. More complex errors relating to a potential lack of DEA understanding of the complex 'conventions' (the rules relating to data collection and input) were also relayed, with inadequate training or a lack of relevant experience prior to qualification pointed to as a possible reason for this.

The perceived value to the public of EPCs was regarded as low amongst DEAs. This is supported by the literature discussed in Chapter 2. Some recommendations were made as to how this value might be improved. Aside from increased remuneration, a more detailed inspection, involving intrusive access to some parts of the property to establish insulation levels and building fabric materials and dimensions was put forward by a number of DEAs as a way in which the accuracy of reports could be improved, and the automated RdSAP reliance upon assumptions reduced. This, it was suggested, might reduce variability and increase trust in reports, which may in turn improve their perception.

Results taken from interviewees would suggest that many DEAs have latched onto the ability to manipulate data inputs to suit their needs. This, it is asserted might be done to enhance a dwelling's energy efficient score to give the appearance of a property that is cheaper to heat and light in the case of sale and rental properties, or to deliberately input less information than might be available to produce an EPC that yields greater carbon savings when insulation measures are applied (due to the defaults of RdSAP tending to revert to a worst-case scenario), a phenomenon that is touched upon earlier in this research in a hypothetical study by Gledhill et al., (2016) and a journal paper identifying precisely this effect published by Ahern in 2020 (Ahern and Norton, 2020). Worse still, there were clear assertions that some DEAs were willfully manipulating RdSAP inputs for personal gain. In addressing potential solutions for this, interviewees pointed to the role of the Accrediting Body as needing to take a firm lead in auditing EPCs, and to reprimand 'rogue' DEAs, and even to help to regulate payment for EPCs for DEAs so that there is greater remuneration, which it was mooted may in turn allow DEAs to spend a more appropriate amount of time in a property collecting data. But there was also a commonly held view that the way in which EPCs are commissioned was not appropriate, and that pressure brought to bear from employers to achieve a particular outcome could at times be hard to resist and does not lend itself well to impartiality.

Finally, it should be noted that the issue of variability of EPCs is central to the focus of the interview questions posited here. As such, the issues picked up from interviewees and reported in this research are those considered most pertinent by the author. Where interviewee information was offered that may directly contrast with the hypothesis mooted at the outset of this research, it is recorded here in the interests of transparency, but equally for transparency, it should be noted that further material was collected from DEAs which was not considered relevant to the study focus and is therefore not included.

4.3.1 Summary and link to the next strand of research

The interview material collected and analysed in this section points unequivocally to EPC variability. The feedback from interviewees is anecdotal, but during this first strand of research, the intention was not to collect hard evidence, but to establish a phenomenon. It may be reasonable to assert at this stage that the phenomenon of EPC variability is known to exist among those producing EPCs. This is because it is unlikely that - even taking into account the limitation of interviewing only a small proportion of all DEAs - with 100% acknowledgement of EPC variability within this study, there would be no such similar acknowledgement of variability among different groups, or larger groups of DEAs elsewhere. So, at a point in the research where there is a known phenomenon, but a lack of hard evidence which may support this, further, linked research may now be wholly justified.

In addition, the interview material can do more than simply warrant further research, it can hone and refine the direction of that research in order to address the research aim more effectively. This is a principle that underpins mixed methods research, and more specifically, the exploratory sequential design as outlined in Chapter 3. Following the collection and analysis of this interview material, some areas of particular interest for the next strand of research may be summarised as follows:

- In discussing variability, dwelling dimensions and dwelling heating systems were noted by interviewed DEAs to be particulary susceptible. The EPC has nearly eighty separate inputs, and studying them all would be a challenge within the research remit. This interview feedback presents an opportunity to refine the EPC data that is given greater focus following completion of the site based EPCs.

- A theme emerged from the interviews about inaequate training and experience, and a lack of relevant understanding. To address this in the next strand of research, a range of DEAs from those without academic and professional qualifications and few years of relevant work related activity, to those who are well qualified and experienced should be sought, so that the quality of EPCs produced by both groups can be crossed referenced for accuracy/variability.

- Interviewees frequently referred to a percieved inadequacy of the audit process. Submitting all test EPCs for audit is not possible, but submission of the control EPC for audit, while unconventional (the auditing body would usually request this of the DEA, not the other way round), may yield interesting results. An attempt should be made to achieve this.

- Criticism of RdSAP's defaults are made by DEAs to a point of saturation in these interviews. Particular attention should be paid in the next strand of research as to how the test EPCs fare against the control, and in particular whether the use of deafaults for missing information has contributed to inaccuracy/variation.

It was considered possible that, having completed this first part of the process, carrying out two site based EPCs may be more effective than one. This would mean splitting the twenty-strong resource into two parts, because time and financial constraints were such that no more than twenty EPCs could realistically be commissioned, nor analysed within the research remit. However, the results from two different properties may bring about more material for reflection on key points made during interviews, such as dwelling dimensions, the default rounding down phenomenon, and overall variation at two different properties, with varying attributes. Other factors contributed to set the research along this route, and this is discussed more in the next chapter.

Finally for this summary, it should be noted that not all feedback from the interviews can be taken forward to the second strand of research for further investigation. In particular, the extensive assertions made by DEAs that conflicts of interest bring about inaccuracies, or worse still that there may be a culture of willful manipulation of data among DEAs to produce the desired result. This is because, if variability is to be established, no external influences can be brought to bear. If they are, there would be questions about the legitimacy of the variation, and what other factors may have contributed to it. This must be marked as a limitation, and is discussed again in the next chapter and marked as an area for further research in the conclusions.

CHAPTER 5. THE QUANTITATIVE STUDY: SITE BASED EPCS

5.1 INTRODUCTION

The first, qualitative strand of research, consisting of 20 interviews with practicing DEAs and discussed in Chapter 4, established that EPC variability is seen to exist among the DEAs themselves. The researcher had a pre-formed hypothesis about the variability of EPC outcomes, but not about the EPC process, or how variability might come about. To this end, the strand 1 research was designed to look at the existence or otherwise of variability as a phenomenon known to DEAs. On the assumption that variability was perceived to exist, it was to obtain the thoughts of DEAs to understand how this might come about, and what might be done to limit variability in future. This first strand of research was not designed to collect empirical evidence for variability, as there were no assurances at the study inception that variability existed, even as a phenomenon. It might therefore be considered justifiable that the existence of variability among DEAs is established first, in order to justify the collection of hard evidence that may (or may not) empirically support this. The methodological approaches analysed, discussed and selected in Chapter 3 identify a study methodology that fits with the series of events as they unfold here. With the strand 1 research having made the case for a second strand of research, and an overarching methodological approach identified, attention is now given to the practicalities of this strand of the research process. However, a brief overview covering methodological and content-related progress thus far along with what is planned for Strand 2 is given next, before continuing with the detail of this strand of research.

5.2 RESEARCH MODEL & RESPONDENT IDENTIFICATION

The research model adopted provides a framework for a second strand of research. The exploratory sequential design was selected in order that a qualitative exploration of the topic could be undertaken as a standalone exercise, prior to embarking on a quantitative study should this be merited. The Strand 2 exercise, consistent with the research model, is to be a quantitative exercise, and the aim of this exercise is to acquire hard data; empirical evidence that may support the emerging theory.

After a review of the options in Chapter 3, the researcher took the view that the most appropriate route to obtaining hard evidence in this strand was to carry out EPCs on site, in order to obtain hard EPC data, captured impartially, for analysis. A control property was selected based on its characteristics (discussed separately later in this chapter), and arrangements were made to have ten EPCs carried out at this property by different DEAs. After administrating the necessary ethical approvals via the university and obtaining supervisor approval, the DEAs who took part in the interview were approached first: contacted as before via telephone or email, and bookings were made to have EPCs carried out at the control property, initially on a 'first come, first served' basis. A period of reflection and provisional analysis would take place after a control EPC was completed by the researcher, where a decision about whether to proceed to undertake 20 EPCs at the same property, or select a different property with different characteristics and split the 20 DEA resource, would be made. Producing more than 20 EPCs was not practical within the confines of the PhD research remit, with only one researcher. The decision was ultimately made to complete the study with a further ten EPCs at a second property, with different characteristics. A hypothesis had emerged following the results of the interviews that this may be a preferable route, because of the information gleaned from the interviewees regarding dwelling dimensions and heating systems, training and expertise, and the frequent criticism of the RdSAP defaults. Two EPCs at different property types would give an opportunity to cross-reference results, as well as to collect a wider range of data including data from more varied dwelling attributes, which could be more helpful in investigating the DEA's perceived shortcomings.

5.3 PRACTICAL CONSIDERATIONS & LIMITATIONS

A number of potential methods of procuring the services of DEAs for this strand 2 exercise were considered. A 'mystery shopper' method of procuring EPCs was a carefully considered option at the outset. Mystery shopper exercises can bring about robust evidence in a range of situations: the method is known to work well in monitoring standards, particularly in commercial situations. Wilson (Wilson et al., 1998), and Finn (Finn, 2001) analysed the mystery shopper approach in the measurement of service performance in commercial situations. Other areas, such as performance within human resources departments or healthcare can be effectively measured with mystery shopper exercises. The information gleaned from mystery shopper studies can be challenging to come by using an alternative route, as the advantages gained are by their definition, unique. But Morrison (Morrison, Colman and Preston, 1997) warn of the influence of the mystery shopper himself, and potential this may have to impact upon data. This may be in part attributed to the reason why a mystery shopper approach is discounted for this strand of research. It was clearly established from the strand 1 DEA interviews that the relationship between those commissioning EPCs and DEAs may be 'loaded', with a clear aim in sight for the commissioner which might carry with it a level of expectation that there may be some degree of facilitation offered, seeing as the DEA is taking their money. This could – and indeed is asserted in strand 1 – bring about variability, the type of which would not be conducive to measuring genuine variability that the researcher seeks to achieve in strand 2.

The study by Jenkins (Jenkins, Simpson and Peacock, 2017), discussed here within the literature review, took the mystery shopper approach to procure EPCs produced for the Green Deal, to look for variability in a broadly similar way to that which is tested here. The mystery shopper approach to procurement of these EPCs may have brought to bear some of what is discussed above: the potential for variability to be built into the process related to producing EPCs for the Green Deal – a 'rounding down' by knowledgeable DEAs of the dwelling's energy efficient characteristics in order to attribute additional savings when measures are applied. Of course, this is only speculation and beyond the unfounded assertions made by the interviewed DEAs there is no evidence to support this, but it is an angle that is not discussed in the Jenkins paper, and which could have had its own impact on the results. Other differences between Jenkins' study and this one should be recapped again in brief, in the interests of making the case that this research is unique and goes further:

- only four EPCs were undertaken at each property in this study, compared to the ten commissioned here;
- of key importance is the access to RdSAP input data in this study. This study gives access for scrutiny of all the inputs for each of the ten EPCs. Jenkins' study did not do this and recognised this as a limitation – they had only the EPCs themselves, which present only a limited 'overview' of the dwelling characteristics. Issues such as the measurement of floor areas, ceiling heights,

exposed wall perimeters and boiler make and model – all of which are known to have a significant, hence very important influence on EPC outcomes (Stone et al., 2014; Palmer and Cooper, 2013) were not available for scrutiny within Jenkins' research.

- finally, within Jenkins' research, a fifth, 'control' EPC was undertaken to benchmark others against, but there is no third-party verfication of this control EPC, and we do not know whether the same DEA completed each control EPC at all 29 properties, or whether different DEAs (employed by the same company) did these. One could argue that this may be no more accurate or reliable than the other EPCs and may not therefore be worthy of status as a control. The researcher here completed both controls himself and made the decision to have a control EPC audited by an Accrediting Body: this may be considered valuable in giving additional legitimacy to its status as a control, even if it must be conceded as a limitation that no DEA can guarantee their EPC is wholly free from erroneous data, and the audit process itself is asserted to be fallible here in this study.

If not adopting the mystery shopper approach, it may be argued that the only viable alternative to procuring services for this study exercise were seen to be to explain its purpose to DEAs and invite them to take part in an academic study. This in itself brings with it, certain limitations. Firstly, and most obviously given the justification for not adopting the mystery shopper approach above: it means there will be no direct evidence collected that may support the DEA's theories regarding the 'deliberate misrepresentation' of EPCs, which DEAs cited as being attributed to their employer's desire to achieve a specific outcome. The strand 2 study will instead seek to establish variability or otherwise where no external influences are brought to bear, but the researcher would argue that this in itself will have clear inferences on whether or not DEAs could manipulate EPC data to their own end. It may be argued that this type of manipulation is more likely if variability exists without external influences, because there is greater potential for ambiguity where variability exists.

The second limitation is that of the Hawthorne effect. This may be summarised in brief as the undesired effect of observation during the carrying out of experimental research. The effect was first identified following a research programme designed to investigate methods of increasing productivity at the Western Electric Company's Hawthorne Works in Cicero, Illinois during the 1920s and early 1930s. It was discovered that regardless of the changes introduced at the Works plant during the study, productivity increased. The effect was described by Franke & Kaul (Franke RH, Kaul, JD, 1978) as 'an increase in worker productivity produced by the psychological stimulus of being singled out and made to feel important'.

The roots of the Hawthorne effect are in industrial research, although its implications have been examined widely and in varying forums, such as clinical research and education (Mayo 1993; Parsons, 1978). It may be generalised as a component of the undesired effect of trial participation, but while its influence is acknowledged as a strong likelihood here in this study, its extent cannot be calculated. McCarney (McCarney et.al., 2007) undertook a study into the magnitude of the Hawthorne effect in a medical research format which yielded some conclusions relating to patient monitoring and outcomes which may be attributed to the Hawthorne effect, along with a potentially quantifiable extent of the effect, but there was an acknowledgement that each observational experiment will have its own characteristics, and the extent of the Hawthorne effect will vary. Also, within the study is discussion of an 'honesty effect', relating to honest reporting of (in this case) clinical data, inferring that this data may not have been so honestly reported had it not been for the Hawthorne, observational effect. This has an interesting ramification for the EPC study, which also calls into question the honesty of DEAs during the interview, strand 1 phase of research. So, it may be important to note that a) any 'interpretation', or 'misrepresentation' of EPC data is unlikely to be accounted for within this study remit, as both the probable existence of the Hawthorne effect and an unknown magnitude of its extent must be marked as a limitation.

The exploratory sequential method should, according to Cresswell (Cresswell et al., 2011), procure different participants for the second strand of study than those who took part in the first. The researcher saw value in a departure from this, recruiting the same DEAs back to take part in the second, site-based exercise. This is because interview remarks can be triangulated with site data, potentially presenting the opportunity to draw additional conclusions, over and above straightforward numeric outcomes. For example, DEAs paid particular attention to dwelling dimensions during their feedback within interviews, and so any variation in size of a dwelling measured by those same DEAs may be interesting to note. In the event, not all DEAs who took part in the first EPC were available to take part in the second, and so a mix of returning DEAs, and new DEAs were procured. This is discussed more with the analysis of the second test EPC later in this chapter.

5.4 STRAND 2 PHASE 1: THE FIRST TEST EPC

5.4.1 Respondent procurement and schedule

The first ten EPCs were undertaken during a three-month period, from 23rd January 2018 to the 20th April 2018. Each was booked at least a week in advance after making telephone or emailed appointments, as discussed in the introduction above. Each DEA was paid a rate consistent with the current market for procuring EPCs: a fee of £50, and each DEA signed the consent forms consistent with the university's ethical approval procedure. In the interests of transparency, the payments were made by the researcher, to the DEA. The individually signed consent forms, along with records of individual payments are also retained by the researcher and available but not included in the appendices of this thesis.

The researcher himself completed a further control EPC at the property, taking site notes and photos on the 16th January 2018 and lodging the EPC (recording it officially with the land registry) on the 19th February 2018. This was completed to the best of the researcher's ability, and then also submitted to the researcher's accrediting body, Elmhurst, for independent audit. The reason for this was to bring as much legitimacy to the control EPC as possible. While variability may be established without a control, the extent of variability and any analysis of error would be more challenging to establish without a baseline. A control, while noted as fallible - and consequently a limitation - provides a benchmark against which to appraise other EPCs. The same procedure was used by Jenkins (Jenkins, (Jenkins, Simpson and Peacock, 2017) in his paper (discussed in the literature review in Chapter 2) which also discusses EPC variability, though the firm undertaking the control EPC did not necessarily use the same DEA (or at least no mention was made as to whether or not they did), and they did not have their control EPCs audited (or again, no mention was made in Jenkins' paper as to whether or not they did). This may then constitute a less reliable control and hence a limitation on their part, although no such mention was made in their paper.

Each EPC commission was the same in scope as would be for any regular EPC instruction, the only difference being that each DEA would record the data on a paper form, for the researcher to input and formally lodge on his DEA account with the land registry. The reason for not allowing the DEAs access to the researcher's account directly to lodge the EPC was because this may have brought about the opportunity for each DEA to see the work completed by other DEAs, including the control EPC inputted by the researcher at the start of the exercise. This might potentially offer them the chance to check and change their own responses. The data was inputted by the researcher into his own account therefore, as opposed to requesting DEAs input the data into their respective accounts, so the researcher would have unimpeded access to each DEA's inputs and accompanying 'xml' data - the data in its raw form - feeding the RdSAP calculator. The paper forms and site notes have been retained by the researcher, and are available upon request, but are not included in the appendices of this research.

In completing the EPC, each DEA would inspect the property externally and from within, non-intrusively, with use of surveyor's ladders, a torch, a laser and tape measure, and a camera. Seven DEAs were noted to use the site notes recommended by their Accrediting Body, while three, DEAs 3, 6 and 10 used their own, pared down site templates. DEAs were timed by the researcher. Notwithstanding opening introductions and a brief recap of the study purpose, the inspection process itself was noted to take from 40 minutes, to 1hr 10 mins. The time it took to complete the site survey appeared to bear no relation to EPC variation.

After the inspection was completed, none of the ten DEAs handed over their forms for data entry, despite this being an option for them. Instead, each requested a short period to reflect and digest their site notes prior to submitting them to the researcher for data entry. Two DEAs, DEA 4 and DEA 8 confirmed they would need to seek advice from the technical department of their accrediting body prior to completing the EPC. It is possible that without the Hawthorne effect and in a regular working environment, DEAs may have entered data directly into the RdSAP model and produced an EPC. This would have seen the commission 'off the desk' for the DEAs, and could have lead to more erroneous data finding its way onto the finalised EPC. However, this is conjecture, and the behaviour of DEAs within the study conditions has been marked already as a limitation.

The ten DEAs taking part in the first tranche of EPCs were professionally and academically experienced as follows:

Table 12 Showing the professional and academic experience of the sample set of DEAs taking part in tranche 1 of the EPC site based study.

Site based EPC study: EPC 1					
DEA	Job title	Background	Academic qualifications	Professional qualifications	Years' experience
1	Valuation surveyor	Social housing	Currently in related FE	Qualified DEA	> 5 years related
2	Energy assessor/Local Authority searc	Conveyancing/Energy surveying	No relevent FE/HE	Qualified DEA/OCDEA	> 15 years related
3	Chartered valuation surveyor	Building Surveying	Relevant Degree	Qualified DEA/MRICS	> 20 years related
4	Technical monitoring officer	Insulation/Energy Surveying	No relevent FE/HE	Qualified DEA/OCDEA	> 15 years related
5	New build acquisitions manager	Social housing	Relevant Masters	Qualified DEA	> 5 years related
6	Valuation surveyor	Social housing	No relevent FE/HE	Qualified DEA	> 5 years related
7	Housing stock condition surveyor	Building Surveying	Relevant Degree	Qualified DEA	> 20 years related
8	Architectural technician	Land surveying / autoCAD technician	Relevant HND level	Qualified DEA	> 20 years related
9	New build completions surveyor	Social housing	Relevant HND level	Qualified DEA	> 10 years related
10	Housing surveyor	Housing stock condition surveying	Relevant Masters	Qualified DEA/OCDEA	> 20 years related

Table 12 shows that all 10 DEAs had built environment related occupations, and that none of them described themselves as DEAs, specifically. Academically, their experience ranged from having no further or higher education (DEAs 1, 2, 4 and 6), to two DEAs with built environment related Masters degrees. While most DEAs would produce EPCs as an essential part of their role, respondents 3, 5, 8 and 9 did not need to produce EPCs as part of their current role. They did during previous roles. All 10 DEAs had more than five years’ built environment related experience (though in a wide range of disciplines) and all had been qualified as a DEA for over five years also. It was not the researcher’s intention to locate DEAs with many years of experience: this came to light after the DEA’s services had been procured. This should be recorded as a limitation, and newly qualified/more recently qualified DEAs may have produced different EPCs to those analysed within this study. However, the *number* of EPCs the DEAs had produced varied considerably, from the high tens in the case of DEA 8, to the hundreds, and in more than half the cases, thousands of completed EPCs. This might be seen as an equally reliable indicator, and a better spread of experience than the number of years that expired since qualifying.

5.4.2 Test property 1 selection and characteristics

At the point of considering what sort of property to select for this phase of the study, the twenty interviews in strand 1 were complete and interview material had been analysed. A draft paper summarising interview results and synthesising the implications of these was submitted to the researcher's supervisor for selection of potential co-authors and possible submission to a journal for peer review. The phenomenon of variability was clearly established, anecdotally, and DEA's opinions as to why this may come about were acknowledged. In selecting a property for the EPC site study and linking this selection process back to the strand 1 study, a number of desirable attributes were established. These may be summarised as follows:

- The property should be traditionally constructed. This, primarily, would best represents the UK's housing stock. This is because non-traditionally constructed buildings may be built in a variety of different ways, with widely varying thermal properties and unique construction methods. Non-traditional housing can require specialist expertise, and it may be argued that this will test DEAs to an unreasonably high level for the purpose of this study. Presenting DEAs with a non-traditionally constructed property would not be representative of a 'typical' UK EPC, and there would be an argument that any variability may be attributed to the uniqueness and complexity of the dwelling type, which is not the intended purpose here. Finally, DEA comments reviewed in strand 1 relating to the age of construction and assumptions made within the RdSAP calculator about wall type and thermal (U) values would be best represented by a traditionally constructed property.
- The dwelling archetype would be representative of the UK housing stock. Terraced houses constitute the largest single proportion of housing stock in the UK: 7.74 million homes are terraced (Palmer and Cooper, 2013). In addition, if selecting an end terrace, the second largest dwelling archetype in the UK - semi detached houses - would also be reflected (7.13 million homes, Palmer & Cooper, 2013).

- In continuing with the argument that the property should be representative of the wider housing stock: a point that underpins this selection process, a pre 1940 property was considered appropriate. This is because the UK's housing stock is among the oldest is the world, and approximately 40% of all housing stock in the UK was constructed prior to 1940 (Dixon, Gupta, 2008).

- Beyond construction, other dwelling attributes should also be considered broadly representative of the UK's building stock. Stone (Stone et al., 2014) and Jenkins (Jenkins et al., 2017) points to heating systems as a key variable within the RdSAP calculator. The anecdotal feedback of DEAs within strand 1 pointed to the same. Hence, the impact of entering an inaccurate heating appliance is significant, when compared with other inputs such low energy lighting, hot water tank insulation, glazing type (Stone et al., 2014; Palmer and Cooper, 2013). A property with mains gas fired central heating was considered ideal, therefore, as this system type is by some 90% of UK households (Palmer, 2013)

- The property should be relatively straightforward to address for the DEA in terms of size and type but represent some challenges. This is more subjective and presented a challenge to the researcher. A simple rectangular terrace with gas central heating may not be considered representative, because few pre-1940 properties are still in their 'as built' form, but what might be considered a challenge, and what might be too complex? This was reviewed again upon completion of the first phase of this site study, where a slightly different view was taken.

The property selected was a pre-1900 two-bedroom end terrace house, constructed with solid sandstone walls under a pitched, tiled roof. To the rear, a circa 1970 constructed two storey rectangular extension had been added, and a single storey glazed kitchen extension was added beyond this. The property measured 95 square meters externally: arguably broadly average size for this type of property and was heated with gas fired central heating via a condensing combination boiler feeding radiators to each room. The property was double glazed throughout, with frames of varying materials and ages. In the interests of transparency, it should be noted that this was the researcher's own home. This was convenient in respect to arranging appointments and scrutinising submitted EPC data (with the subject property available to revert back to whenever necessary), but also in terms of the intimate knowledge the researcher had of the property, which may be considered useful in adding some degree of credence to the quality of the control EPC (though by no means conclusive in respect to robustness of the control).

Photographs of the front and rear elevations of the property and some key components are presented below. The complete photo set is not considered essential to the research focus and so not included in the body of this chapter, but it was provided for audit - the feedback for which can be seen in Appendix J, and the photo set is included in Appendix I.

Image 1. Control property for phase 1 of the EPC site study.

Image 2. Rear elevation of control property for phase 1 of the EPC study, showing two storey circa 1970 extension, and glazed kitchen extension beyond this. The building that adjoins the kitchen extension to the left hand side of this photograph belongs to the neighbouring property.

Image 3. The vaulted first floor ceiling to the original dwelling is an unusual feature, which may not be considered representative of the wider UK housing stock. This was a feature considered reasonable to test the DEA's ability, the justification for which is that many properties may have a small number of interesting or unusual features that may have warranted some further investigation.

Image 4. Condensing combination boiler, located in the front bedroom. Make and model are clearly identifiable toward the bottom left hand corner of the photograph, and the model 'qualifier' (the specific model type) is visible on the sticker toward the top right hand corner of the photograph

Image 5. Solid fuel 'closed' heater, or stove, cited in the living room.

5.4.3 Test property 1 control EPC

The photographs in the section above (along with the full photo set in Appendix I) show the key energy efficient components of the property selected for the first half of the site-based EPC study. To summarise in brief, this is a pre-1900, traditionally constructed two-bedroom end terrace house with gas central heating, double glazing and a wood burning stove to the living room. There is a two-storey extension on the back. These dwelling attributes may be considered broadly typical of a vast number of properties in the West Yorkshire and wider area, and the property was selected on this basis.

Variability may be established without a control but having a baseline to refer back to offers the potential to measure a margin of error. This would not be possible otherwise. Also, surveyor 'drift' has been discussed earlier in this research. Surveyor drift is a phenomenon Kempton (Kempton et al., 2000) identified as groups of surveyors en-masse scoring their opinion about the condition of a building component, or group of components in a certain way at one point in time, but having been found to have moved, as a group, to score the same component/s differently some time later. Clearly this phenomenon would have an impact on the collected survey data and published results. The research here identified the potential for there to be not only surveyor drift in the way Kempton identified it, possibly attributed to the DEA's perception of how a building such as this – one that is over 100 years old – may perform, but also automated RdSAP bias, where missing, or unavailable information defaults to a worse case scenario. Furthermore, intentional bias (or 'willful misrepresentation' as it has been categorised in the interviews in Chapter 4) might be a consideration in some circumstances, where for example a particular outcome is desired by the party commissioning the report (such as that potentially brought to bear as an unintended consequence of commissioning the Green Deal study as a mystery shopper exercise, discussed in Jenkins' paper (Jenkins et al., 2017). Any intentional bias or misrepresentation would not be established within the study scope here, because the EPC was intentionally commissioned with no specific aim or outcome in mind. This is an important decision, and which ever choice was made would have to be marked as a limitation. This is discussed in more detail in the discussion section of this chapter, and within the thesis conclusions. This system of procurement was considered the most appropriate to establish EPC variability. But other issues, such as the identification of erroneous data, surveyor drift, or automated bias would only be picked up if a control existed to compare results against, and these are issues that fall within the study scope, and so a control adds value to the research.

The control EPC was completed by the researcher on site on the 16th January 2018, before any of the study EPCs were undertaken. The work consisted of drawing up carefully measured floor plans and filling out site notes and taking photographs. The inspection required the use of a torch, camera, and surveyor's (2.4m telescopic) ladders. The inspection took 50 minutes, but this did not include entering the data into the RdSAP model to produce the EPC itself. This was completed two days later, and took a further one hour and forty minutes, so the whole operation took two and half hours in total. This may be seen as a relatively long time to complete an EPC, which may more typically (according to interview respondents in strand 1) take between one and two hours inclusive, depending on the complexity of the building. The researcher was keen to ensure the quality of the EPC was high and no erroneous data was included, and so everything was double checked. The researcher contacted the accrediting body with whom he is registered, Elmhurst, and requested that this control EPC be audited. This may be considered quite an unusual request, as Elmhurst's audit procedure works the opposite way around: they will contact the DEA by email and request site notes and photos when an audit is required. But after having explained the purpose of the research to Elmhurst and sending them the participant information form for information (see Appendix E), they agreed to audit the EPC on request in this instance. The reason for requesting an audit was the additional credence, or robustness this would add to the control's legitimacy. While the researcher may simply draw up and lodge a control EPC without auditing (this is the way the control was provided in the study by Jenkins (Jenkins et al., 2017) and this would provide a useful benchmark by which to measure variation, it would not preclude the possibility of errors being contained within the control. While there is never a guarantee that the EPC is free from errors - and indeed many of the DEAs made assertions about the fallibility of the audit process within their interviews - the checks undertaken by the Accrediting Body, especially where no pressure is brought to bear and the researcher is making best endeavors to generate an accurate report, may be seen as increasing the level of authenticity. In this particular instance, the audit led to some useful feedback which, should the same oversight have been made with one of the control EPCs in the study by Jenkins, would not have been picked up.

After lodging the EPC and submitting it for audit on January 18th, 2018, the researcher was contacted by Elmhurst's audit department on the 16th February 2018 and informed that there was an error in the first submitted EPC. The mistake related to the passageway underneath the building, which was acknowledged but not recorded correctly as an 'alternative' (sheltered) wall in the first submission. While this may call the competence of the researcher into question, the experience yielded some interesting conclusions. Firstly, the auditing process successfully highlighted an inaccuracy in the researcher's EPC. This was not necessarily an easily identified error, and this might be seen as proof that the audit process is effective, when evidence, including photographs are made available that would facilitate a desktop-based appraisal. This is consistent with the feedback given by interviewees in strand 1. They highlighted the audit process as fallible, but not wholly ineffective. So, where site-based information is submitted to auditors and erroneous data can be identified from a desktop appraisal, it can be confirmed within the experience of this part of the study that issues do get picked up.

In addition to having received an EPC audit-related experience that was not anticipated, but yielded interesting results, the error in the submitted EPC may also serve to confirm that there is some additional legitimacy in having a control EPC audited. The site information and photographs clearly had more than just lip service paid to them by auditors, because the erroneous data was not easy to identify. This may serve as compelling evidence that the control EPC is more robust for having been subjected to audit.

Finally, the audit reinforced the complexity of the EPC, which contributed toward the decision-making process that led to the selection of two test properties, rather than one. The researcher has been completing EPCs since their inception in 2008 and has a collection of professional and academic qualifications that indicate his status as a competent DEA. In addition, the mistake was made after particularly careful checking of the EPC data prior to submission of the report. It should be noted therefore, that this property may be considered quite complex: with traditional and commonly found features, as was intended, but a greater level of complexity than may originally have been intended. To balance this, a second property will not only have differing attributes that are commonly found, like this one, but it will be a more basic overall proposition.

This may balance the overall scale of variability and bring some context to the respective data yielded from each dwelling.

The researcher's EPC was checked again and approved by Elmhurst auditors upon resubmission on the 19th February 2018. The email confirming the EPC passed audit is contained in Appendix I, and the four-page EPC itself is laid out below.

Energy Performance Certificate

HM Government

7, Stoney Lane, Chapelthorpe, WAKEFIELD, WF4 3JN

Dwelling type:	End-terrace house	**Reference number:**	8428-6129-7160-5966-6996
Date of assessment:	16 January 2018	**Type of assessment:**	RdSAP, existing dwelling
Date of certificate:	19 February 2018	**Total floor area:**	95 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

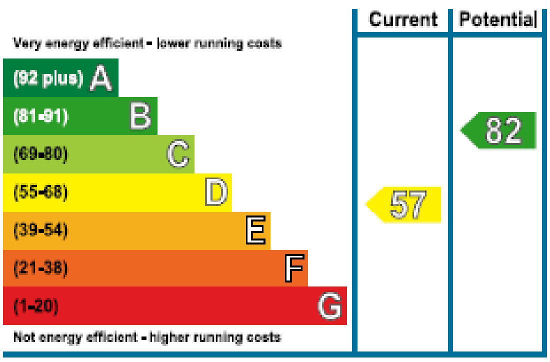
Estimated energy costs of dwelling for 3 years:	**£ 3,369**
Over 3 years you could save	**£ 1,275**

Estimated energy costs of this home

	Current costs	Potential costs	Potential future savings
Lighting	£ 219 over 3 years	£ 219 over 3 years	You could save £ 1,275 over 3 years
Heating	£ 2,838 over 3 years	£ 1,659 over 3 years	
Hot Water	£ 312 over 3 years	£ 216 over 3 years	
Totals	**£ 3,369**	**£ 2,094**	

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.

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

Recommended measures	Indicative cost	Typical savings over 3 years
1 Flat roof or sloping ceiling insulation	£850 - £1,500	£ 591
2 Cavity wall insulation	£500 - £1,500	£ 132
3 Internal or external wall insulation	£4,000 - £14,000	£ 456

See page 3 for a full list of recommendations for this property.

To find out more about the recommended measures and other actions you could take today to save money, visit www.gov.uk/energy-grants-calculator or call **0300 123 1234** (standard national rate). The Green Deal may enable you to make your home warmer and cheaper to run.

Page 1 of 4

Above: Control EPC Page 1. Below: Control EPC Page 2.

Summary of this home's energy performance related features

Element	Description	Energy Efficiency
Walls	Sandstone or limestone, as built, no insulation (assumed)	★☆☆☆☆
	Solid brick, as built, no insulation (assumed)	★☆☆☆☆
	Cavity wall, as built, no insulation (assumed)	★★☆☆☆
Roof	Pitched, no insulation (assumed)	★☆☆☆☆
	Flat, no insulation (assumed)	★☆☆☆☆
Floor	Solid, no insulation (assumed)	—
	To external air, no insulation (assumed)	—
Windows	Fully double glazed	★★★☆☆
Main heating	Boiler and radiators, mains gas	★★★★☆
Main heating controls	Programmer, room thermostat and TRVs	★★★★☆
Secondary heating	Room heaters, dual fuel (mineral and wood)	—
Hot water	From main system	★★★★☆
Lighting	Low energy lighting in 85% of fixed outlets	★★★★★

Current primary energy use per square metre of floor area: 308 kWh/m² per year

The assessment does not take into consideration the physical condition of any element. 'Assumed' means that the insulation could not be inspected and an assumption has been made in the methodology based on age and type of construction.

See addendum on the last page relating to items in the table above.

Low and zero carbon energy sources

Low and zero carbon energy sources are sources of energy that release either very little or no carbon dioxide into the atmosphere when they are used. Installing these sources may help reduce energy bills as well as cutting carbon. There are none provided for this home.

Your home's heat demand

For most homes, the vast majority of energy costs derive from heating the home. Where applicable, this table shows the energy that could be saved in this property by insulating the loft and walls, based on typical energy use (shown within brackets as it is a reduction in energy use).

Heat demand	Existing dwelling	Impact of loft insulation	Impact of cavity wall insulation	Impact of solid wall insulation
Space heating (kWh per year)	17,439	N/A	(890)	(2,989)
Water heating (kWh per year)	2,226			

You could receive Renewable Heat Incentive (RHI) payments and help reduce carbon emissions by replacing your existing heating system with one that generates renewable heat, subject to meeting minimum energy efficiency requirements. The estimated energy required for space and water heating will form the basis of the payments. For more information, search for the domestic RHI on the www.gov.uk website.

Recommendations

The measures below will improve the energy performance of your dwelling. The performance ratings after improvements listed below are cumulative; that is, they assume the improvements have been installed in the order that they appear in the table. Further information about the recommended measures and other simple actions you could take today to save money is available at www.gov.uk/energy-grants-calculator. Before installing measures, you should make sure you have secured the appropriate permissions, where necessary. Such permissions might include permission from your landlord (if you are a tenant) or approval under Building Regulations for certain types of work.

Recommended measures	Indicative cost	Typical savings per year	Rating after improvement
Flat roof or sloping ceiling insulation	£850 - £1,500	£ 197	D65
Cavity wall insulation	£500 - £1,500	£ 44	D66
Internal or external wall insulation	£4,000 - £14,000	£ 152	C72
Solar water heating	£4,000 - £6,000	£ 33	C73
Solar photovoltaic panels, 2.5 kWp	£5,000 - £8,000	£ 271	B82

Alternative measures

There are alternative measures below which you could also consider for your home.

- External insulation with cavity wall insulation

Opportunity to benefit from a Green Deal on this property

Green Deal Finance allows you to pay for some of the cost of your improvements in instalments under a Green Deal Plan (note that this is a credit agreement, but with instalments being added to the electricity bill for the property). The availability of a Green Deal Plan will depend upon your financial circumstances. There is a limit to how much Green Deal Finance can be used, which is determined by how much energy the improvements are estimated to **save** for a 'typical household'.

You may be able to obtain support towards repairs or replacements of heating systems and/or basic insulation measures, if you are in receipt of qualifying benefits or tax credits. To learn more about this scheme and the rules about eligibility, call the Energy Saving Advice Service on **0300 123 1234** for England and Wales.

About this document and the data in it

This document has been produced following an energy assessment undertaken by a qualified Energy Assessor, accredited by Elmhurst Energy Systems Ltd. You can obtain contact details of the Accreditation Scheme at www.elmhurstenergy.co.uk.

A copy of this certificate has been lodged on a national register as a requirement under the Energy Performance of Buildings Regulations 2012 as amended. It will be made available via the online search function at www.epcregister.com. The certificate (including the building address) and other data about the building collected during the energy assessment but not shown on the certificate, for instance heating system data, will be made publicly available at www.opendatacommunities.org.

This certificate and other data about the building may be shared with other bodies (including government departments and enforcement agencies) for research, statistical and enforcement purposes. For further information about how data about the property are used, please visit www.epcregister.com. To opt out of having information about your building made publicly available, please visit www.epcregister.com/optout.

Assessor's accreditation number:	EES/006272
Assessor's name:	Mr. Toby Gledhill
Phone number:	01924 249970
E-mail address:	toby@w-y-p.co.uk
Related party disclosure:	Residing at the property

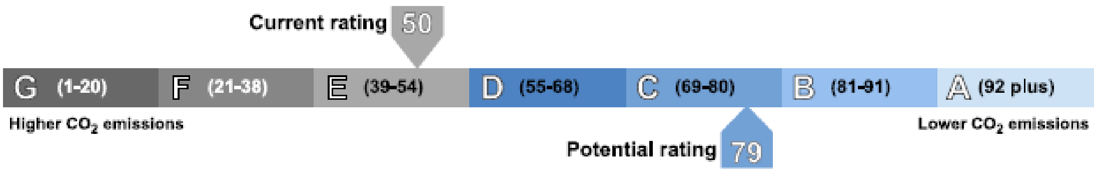
There is more information in the guidance document *Energy Performance Certificates for the marketing, sale and let of dwellings* available on the Government website at: www.gov.uk/government/collections/energy-performance-certificates. It explains the content and use of this document, advises on how to identify the authenticity of a certificate and how to make a complaint.

About the impact of buildings on the environment

One of the biggest contributors to global warming is carbon dioxide. The energy we use for heating, lighting and power in homes produces over a quarter of the UK's carbon dioxide emissions.

The average household causes about 6 tonnes of carbon dioxide every year. Based on this assessment, your home currently produces approximately 5.3 tonnes of carbon dioxide every year. Adopting the recommendations in this report can reduce emissions and protect the environment. If you were to install these recommendations you could reduce this amount by 3.1 tonnes per year. You could reduce emissions even more by switching to renewable energy sources.

The environmental impact rating is a measure of a home's impact on the environment in terms of carbon dioxide (CO_2) emissions based on standardised assumptions about occupancy and energy use. The higher the rating the less impact it has on the environment.



Addendum

This dwelling has stone walls and so requires further investigation to establish whether these walls are of cavity construction and to determine which type of cavity wall insulation is best suited.

5.5 TEST EPC 1 RESULTS

5.5.1 Test property 1 EPC analysis

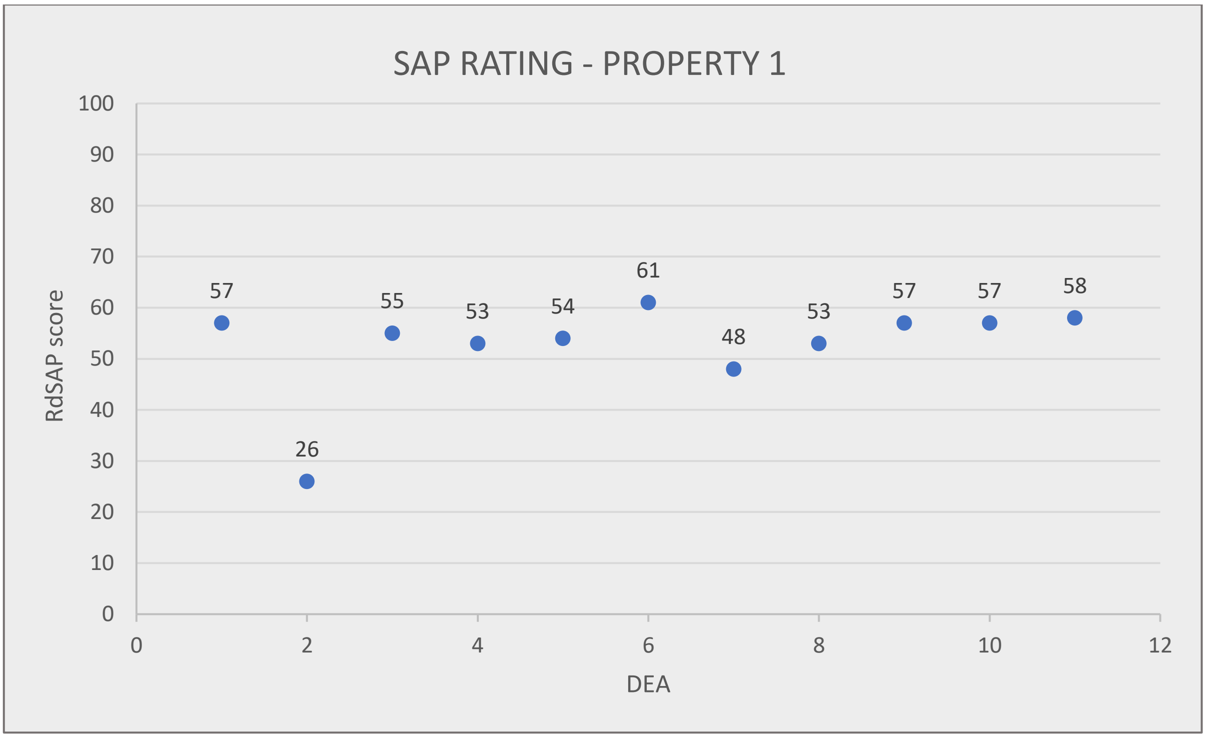
The control EPC, displayed in full above, recorded the property's RdSAP rating as Band D 57. This is displayed on the first page of the certificate. This may be considered the 'headline' figure from the EPC, and a reasonable place to start with the analysis. So, to begin with, the ten test EPCs may be compared against this control, using just their RdSAP ratings. The table below shows the control EPC's RdSAP rating and score, along with those of the EPCs carried out by the DEAs in phase 1 of the Quantitative strand 2 study.

Table 13. RdSAP ratings and scores for test EPC 1, including overall mean and standard deviation for test EPCs only. Quantitative study research strand 2

	SAP Band	SAP Rating
CONTROL	D	57
DEA 1	F	26
DEA 2	D	55
DEA 3	E	53
DEA 4	E	54
DEA 5	D	61
DEA 6	E	48
DEA 7	E	53
DEA 8	D	57
DEA 9	D	57
DEA 10	D	58
Test EPCs Mean	**E**	46.5
Test EPCs Standard Deviation	10.95	

Restricting analysis at the outset to just the RdSAP ratings above, the test EPC was attributed a rating spanning three RdSAP bands, and 35 SAP points across the eleven EPCs. Only seven bands exist on the RdSAP scale: A to G, and SAP scores span from 1 to 100. Immediately then, variability is seen to exist. To have a variation of 35 SAP points for one property, on a scale totaling 100 points may be seen as remarkable. To show this in context, the results for this one property may be seen within the entire SAP scale of 1 to 100 in scatter form in Table 14 below.

Table 14. RdSAP scores for test EPC 1. Quantitative study research strand 2



In looking at the figures more carefully, an early observation is that the control EPC can be seen to sit toward the top of the range of ratings that are attributed to the property. At 57, it is joint third highest of the eleven scores, with the scale peaking at 61, dropping to 58, and (including the control EPC) three EPCs all scoring 57.

Four SAP points (from the control of 57 to the highest test EPC of 61) may be seen as a large margin with serious implications, but by far the largest margins were found below the level of the control EPC, where six of the eleven EPCs were recorded. The lowest level of 26 (from DEA 2), arguably an outlier, or anomalous score in a range that would have otherwise spanned 13 SAP points (DEA 7's 48 to DEA 6's 61), is 31 SAP points lower than the control EPC's score; less than half the control's score. The second lowest level of 48 is 9 SAP points lower than the control, and DEA's 4 and 8 are both 4 points lower than the control. During interviews, the defaulting 'rounding down' of RdSAP where there is limited information, or information is missing altogether, was criticised. This is borne out in the results here, where the mean of the ten test EPCs is more than ten SAP points lower than the control EPC's score. This too is interesting, because while the research may point to variation, in larger numbers one might hope to see this variation averaging out to give a reasonable indication of housing stock when analysis on a larger scale is undertaken, such as that within the English Housing Survey. The results here would appear to contradict this, and while only limited conclusions may be drawn from a sample of ten, it is interesting to note the scale of variation between the mean and the control: a whole SAP band in this instance.

Palmer and Cooper (DECC, 2013) model uncertainty in housing energy within their Housing Energy Fact File. Post 2007, the data relied upon comes primarily from RdSAP scoring of properties either within the English Housing Survey, or from energy efficient schemes such as the CERT and CESP schemes discussed earlier in this research, and the current Energy Company Obligation (ECO) (Ofgem, 2013). The ECO also reported progress using RdSAP from its inception in 2013 until April 2017. Palmer and Cooper's uncertainty modelling in their Housing Energy Fact File is discussed in Appendix 4 of the document. Consideration is given when modelling this error to more than just the RdSAP model and human error (heating demand and climate data are also considered), and so it would be wrong to make direct comparisons, but the modelling error does not specifically account for an automated 'rounding down' factor within RdSAP. Since there are no external factors brought to bear due to the way the EPC was commissioned, and even with the influence of the Hawthorne effect which may go some way to 'artificially' improving accuracy (and is discussed earlier in this chapter) this range of values below the level of the control and the large disparity between the control and the mean may be attributed in part to the rounding down of RdSAP, although variability across the range may be primarily attributed to errors in data collection and entry. More detailed analysis of EPC inputs is required to establish how this variability may have come about, and consideration is given to this after analysis of the results themselves, and the discussion section of this thesis.

Analysis of the mean of these SAP scores has yielded interesting results. Potentially of less interest in isolation at this stage is a calculation of standard deviation: 10.95 in this instance. This is given in cogniscance of the government's own guidance that there be no more than +/-5 SAP points of error within 95% of all assessments (which equates to two standard deviations: less than a fifth of that seen here)(DECC, 2011), but also because the second phase of strand 2 where a further 10 EPCs are produced on an entirely different building will allow scope for comparison. Being only a relatively short step beyond calculating a mean, standard deviation is considered an appropriate method for comparison between the two sets of results and may provide some interesting context for how DEAs perform when addressing varying degrees of complexity.

Stone (Stone et al., 2014) undertook a study into the key building components that influence RdSAP variance. Their study was a desk-based exercise, analysing existing English Housing Survey (EHS) data by converting it back into RdSAP inputs and modelling the inputs using Monte Carlo samples, then analysing the distribution. With these, they produced sensitivity analyses for each building component which may influence energy efficiency and ordered these by the extent their influence can vary overall outcome. This may be seen as a useful study to feed into this research, because RdSAP contains a total of 74 inputs, and it may be considered necessary to reduce these down to a number of key components for more careful analysis. For instance, in the interests of bounding the research, common sense may dictate that there would be greater value for the reader in presenting the effects of varying measured floor areas and heating systems here, over the proportion of light fittings containing low energy bulbs, but some literature is needed that may justify a robust prioritization of each of these components.

The study by Stone focused on those elements which had the largest contribution to the observed variance of energy rating, based on the RdSAP section of the English Housing Survey data sets from 2009. The study focused on gas centrally heated houses only and excluded flats and maisonettes: a ground floor and a roof were a prerequisite. Beyond this, no particular dwelling archetype (i.e., detached, terrace) dwelling age, or other restrictions were placed on the sample group selected, although the information relates to existing housing stock only, which is consistent with the study scope here. The approach taken may give rise to potential for error in its conclusions, though, and this should be noted. The sensitivity of a particular input – a dwelling attribute – is measured by the observed variation in the input across the stock. In Stone's paper, a higher sensitivity would indicate *either* that the model is very sensitive to that input, or that there is a wide range in observed values across the stock, or a combination of these. This brings about a degree of ambiguity to the published results. Stone found that the greatest impact was in relation to dwelling geometry – the overall size of the building's volume, but it may be reasonable to assert there is likely to be a greater variation in building geometry than, for example, in the thickness of hot water cylinder jacket insulation, or heating controls, simply by virtue of the fact houses vary considerably in size. While not specifically recorded as a limitation in the paper, this is discussed, and even if not wholly robust, this analysis provides compelling evidence for a prioritization of dwelling attributes. Stone found the first three dwelling attributes with the greatest potential variance were dwelling geometry, heating system efficiency, and external wall U-value (the assumed thermal efficiency of walls as a standalone component). These three components alone are shown by Stone to account for over 75% of the variance in SAP rating and Environmental Impact (EI) rating, and this is used here as justification for analyzing these inputs in the case study EPCs.

5.5.2 Test property 1 dwelling geometry

It may be seen as unsurprising that dwelling geometry was found by Stone to carry the greatest variance within the EPC. This is because the term in this case refers to a number of important RdSAP inputs. Dwelling geometry, while being related primarily to dwelling floor area, is not limited to this. Geometry also refers to two further key attributes: ceiling heights and 'heat loss perimeter'. The heat loss perimeter is the perimeter of the building that is exposed to the open air, as opposed to that which is attached to other properties. A square shaped mid terrace house, for instance, might have a total perimeter around the edge of the building of 5x5 meters: 20 linear meters, but 50% of this perimeter would be attached to the buildings either side of it, so its heat loss perimeter would be 10 linear meters. Thus, RdSAP assumes it loses heat only through 50% of its perimeter. Clearly a detached building with the same dimensions will lose heat across its entire perimeter: twice as much as the terraced house, despite their both having the same total floor area. Assuming all other dwelling attributes are equal, the terraced house would therefore be the more energy efficient, with a higher RdSAP score.

Ceiling heights may be seen as equally important within dwelling geometry, because RdSAP needs to determine the volume of space being heated. Clearly, (again with all other things being equal) the greater the volume of space, the higher the cost and hence the lower the RdSAP score.

With dwelling geometry having three key variables, results can be nuanced. For example, a terraced dwelling with high ceilings and a large floor area may yield a higher (a more efficient) SAP score than a smaller detached house with lower ceilings, which may superficially appear more efficient. This may be due to the more efficient heat loss perimeter of the terraced house: it has a larger space to heat, but it is retaining more heat within its walls. Results can become more opaque when combined with other RdSAP inputs, such as heating system efficiency: the next most important variable on the list of Stone, discussed above. Even within the parameters set by Stone, of scrutinizing only dwellings with gas fired central heating, common sense may well dictate that a 20-year-old boiler will be less efficient than a new one, and in two dwellings with the same geometry: floor area, ceiling height, and heat loss perimeter (and all other inputs being equal) RdSAP will attribute a higher heating cost to the dwelling with the older boiler, hence a lower SAP score.

This is borne out in the results of the study here, displayed in Table 15 below. As with SAP scores, there is considerable variation in floor areas measured, but these are not wholly consistent with the RdSAP scores. The test property was measured at 83.55 square meters in the control. In the test EPCs measurements of the same dwelling were as little as 66.01 square meters, and as much as 86.42 square meters. This equates to a standard deviation of 5.84 across the data set of test EPCs. A further measurement of 94.26 square meters was submitted by DEA 2, although they misunderstood the RdSAP conventions relating to conservatories (an issue in itself which will be discussed later) and had mistakenly added the glazed conservatory to the rear of the property onto the main dwelling floor area, instead of counting it separately. The figures for this are presented in italics and are not included in the mean or standard deviation calculations, because they may be seen as inconsistent with the other figures.

In order to establish the direct effect, the variation of floor areas has on RdSAP outputs, the recorded floor areas would need to be entered into an EPC with all other inputs equal.

In this case, the control EPC's inputs could be a useful substitute, but in the interest of bounding the research, and not (to some degree) replicating the work of Stone as well as Palmer and Cooper, this is not undertaken here. In the absence an empirical exercise however, it may nonetheless be reasonable to assert that DEA 7's 66.01 sqaure meter test EPC would yield a markedly different RdSAP score with a floor area in excess of 20% smaller than the control property's 83.55 square meter internal floor area, all other inputs being equal.

Table 15 showing RdSAP bands, SAP scores, and dwelling geometry data for the control EPC and all ten test EPCs, including mean and standard deviation. Study strand 1, phase 2.

	SAP Band	SAP Rating	Total Internal Floor Area	Conservatory Floor Area	Total Ceiling Height (Averaged)	Total Heat Loss Perimeter (HLP)	Conservatory Y/N	Conservatory HLP	Passageway Y/N (Exposed first floor)
CONTROL	D	57	83.55	11.92	2.30	39.09	Y	2.87	Passageway (5.55m2)
DEA 1	F	26	86.42	10.35	2.20	40.58	Y	3.36	No
DEA 2	D	55	*94.26*	N/A	2.42	*38.77*	N	N/A	Passageway (5.58m2)
DEA 3	E	53	81.11	11.50	2.24	40.27	Y	3.05	No
DEA 4	E	54	82.57	10.92	2.28	41.60	Y	2.95	Passageway (5.53m2)
DEA 5	D	61	85.79	11.05	2.15	35.04	Y	3.12	No
DEA 6	E	48	85.81	10.35	2.11	41.32	Y	3.36	No
DEA 7	E	53	66.01	11.00	2.50	28.50	Y	2.90	Passagway (5.52)
DEA 8	D	57	83.25	11.59	2.29	39.67	Y	3.10	No
DEA 9	D	57	82.33	10.97	2.16	33.83	Y	3.12	No
DEA 10	D	58	82.77	11.27	2.44	38.30	Y	2.85	Passageway (5.59)
Test EPCs Mean	**E**	46.5	81.78	11.00	2.28	37.68		3.09	
Test EPCs Standard Deviation	10.95		5.84	1.24	0.13	4.14		0.17	

In moving on from the dwelling floor area, but still under the heading of geometry, the heat loss perimeter is shown in Table 15 above to have the greater standard deviation after the overall SAP scores and total internal floor areas. Heat loss perimeter then, after floor area measurement, is the input with the greatest variability among the test EPCs. The mean of both internal floor area and heat loss perimeter is less than their counterparts within the control, and actually by a similar margin: between 1 and 2 square meters. Common sense may dictate that the consequence of this would be to increase overall efficiency of the dwelling slightly, as the mean has a smaller floor area, and less exposed wall than the control, but the mean is actually much less efficient than the control, and other factors outside of geometry must explain this.

Fueling this particular conundrum is the narrow passageway underneath the building: see Images 1 and 3 in Section 5. More than half of the DEAs did not reference this passageway and their data entry. The consequence of this might further serve to bring efficiency up, as a section of exposed floor to the upper level (the bedroom, in this instance) has not been recorded: the bedroom floor inaccurately recorded as being above a heated space in all six of these EPCs. Counter balancing this to an unknown extent is the existence of a 'sheltered wall', however, which is included in all correctly logged 'passageway' EPCs but in none of those where the passageway is not included (the ground floor side elevation wall facing into the passageway is sheltered and recording it as such reduces the heat loss coefficient calculated from this wall by RdSAP). The effect of this might be to increase heat loss through wall exposure of the non-passageway EPCs, but reduce it through the bedroom floor, and vice versa on the 'passageway' EPCs. As noted earlier in this section, only an EPC drafted with this specific data, and identical control data for all other inputs would give definitive results for the effect of the passageway.

Ceiling heights, conservatory floor area and conservatory heat loss perimeter yielded standard deviations of under 1.25, rendering them comparatively reliable in relation to other dwelling geometry inputs. Even with this increased reliability however, it is likely that there would be a notable effect on RdSAP score when comparing the highest and lowest ceiling height inputs: for example, the reduction in volume of heated space that DEA 6's RdSAP calculation would have yielded with a ceiling height of 2.11 over that of DEA 7's EPC with a ceiling height of 2.50. Note that this ceiling height is averaged across the whole floor area of the dwelling.

5.5.3 Test property 1 heating system

Stone refers to main heating system efficiency: this is essentially the boiler efficiency only, and not heating controls (which they score separately, as having an influence some way down the list of key factors), nor secondary heating systems, which they also believe to have less of an impact. This section looks primarily at the heating boiler therefore, and commentary will extend later to look at heating controls and secondary heating. The table below may be seen as a useful reference point for the discussion.

Table 16 showing RdSAP bands, SAP scores, EI bands and EI scores, and dwelling heating appliances and controls for all ten test EPCs. Study strand 1, phase 2.

	SAP BAND	SAP RATING	EI BAND	EI RATING	Emissions t/year	Estimated fuel bill/£year	Heating fuel	Boiler PCDF	Boiler efficiency	Heating controls	Water heating	Secondary heating
CONTROL	D	57	E	50	5.317	1123	Mains Gas	10328	88.8	Programmer, room stat, TRVs	From main (no cylinder)	Closed room heater
DEA 1	F	26	E	49	5.466	1694	Bulk LPG	16844	90.3	Programmer, room stat	From main (no cylinder)	Closed room heater
DEA 2	D	55	E	47	5.603	1187	Mains Gas	10328	88.8	Programmer, room stat	From main (no cylinder)	Closed room heater
DEA 3	E	53	E	51	5.060	1215	Mains Gas	10328	88.8	Programmer, room stat, TRVs	From main (no cylinder)	Closed room heater
DEA 4	E	54	E	46	5.714	1208	Mains Gas	10328	88.8	Programmer, room stat	From main (no cylinder)	Closed room heater
DEA 5	D	61	D	59	4.292	1029	Mains Gas	16839	89.3	Programmer, room stat, TRVs	From main (no cylinder)	Closed room heater
DEA 6	E	48	E	45	6.023	1373	Mains Gas	N/K Default Used	N/A	Programmer, room stat, TRVs	present (no access)	Closed room heater
DEA 7	E	53	E	52	4.394	1064	Mains Gas	10328	88.8	Programmer, room stat, TRVs	From main (no cylinder)	Closed room heater
DEA 8	D	57	E	50	5.295	1128	Mains Gas	10328	88.8	Programmer, room stat, TRVs	From main (no cylinder)	None
DEA 9	D	57	D	55	4.589	1105	Main Gas	10328	88.8	Programmer, room stat	From main (no cylinder)	Closed room heater
DEA 10	D	58	D	56	4.547	1086	Mains Gas	10328	88.8	Programmer, room stat, TRVs	From main (no cylinder)	Closed room heater

The heating system at the subject property may be considered relatively simple. It consists of a condensing combination boiler, manufactured by a well-known brand which sells to a respectable share of the market. At the time of writing, the boiler is a current model, and both its brand and model 'qualifier' (the serial number which denotes precisely which model it is) were easily accessed, on the front panel of the boiler which was located in an airing cupboard off the main bedroom. See Image 8 in Section 5 for the boiler (and also Images 9, 10 and 11 for secondary heating, and heating controls). Equally, the secondary heating system: the wood burning stove in this case, was clearly visible in the main (and only) reception room as something of a focal piece, and the smart thermostat and thermostatic radiator valves were identifiable as one might expect. Despite this, only three of the ten DEAs identified both primary and secondary heating systems as well as heating controls correctly.

Here, it is interesting to note the impact of one key error over all others. The Band F rated EPC submitted by DEA 1 has been contributed to by numerous inaccuracies, but the selection of Bulk LPG as the primary heating fuel (liquid propane gas, as opposed to mains gas) has had the most significant impact on the SAP band and score. This error is attributed to an incorrect boiler 'ID' being entered into the RdSAP model. It is however worthy of note that while the SAP score is heavily detrimentally affected, this is due to the cost of LPG compared with mains gas, and the EI (environmental impact) score and total estimated annual carbon emissions remain broadly consistent with the other EPCs.

Other inaccuracies here also have a marked effect, consistent with the findings of Stone. After the anomalous score presented by DEA 1's EPC, DEA 6 offers up the next-worst SAP score, at 48. This may also be in large part attributed to heating, as they were unable to identify the boiler type and instead inputted a default boiler into RdSAP, intended for use only when the boiler qualifier is not available. Unfortunately, DEA 6 incorrectly guessed the boiler type, and assumed this was a (less efficient) 'system' boiler, with a hot water tank (as opposed to a combination boiler, which does not need a hot water tank). This assumption is likely to have had a significant direct impact on the overall SAP score.

Other notable omissions are those of DEA 8, who missed the secondary heating system altogether, DEA 5, who inputted an incorrect boiler qualifier and whose EPC benefitted from a more efficient boiler as a result (DEA 5's EPC was in fact the highest scoring of all 10 EPCs, and this may be in part attributed to this). And four DEAs who missed the two thermostatic radiator valves (TRVs) in the property, which would have otherwise helped to lift the scores just a little higher.

5.5.4 Test property 1 external wall U-value

Estimating the age of a dwelling can be a challenging process. In most cases it is unlikely that documentary evidence will be available to confirm this and identifying architectural features that may define a period may be the domain of an experienced surveyor. For the DEA, this is an important skill. With each RdSAP age band, a different wall U Value (the heat loss coefficient attributed to a single building component) will be set to a specific figure which will improve as build dates are recorded closer to the present day. The more recent date bands in RdSAP are set in line with building regulation updates: Part L of the building regulations being the relevant section (Part L relates to energy efficiency). A table of the RdSAP age bands is laid out below, along with the U Values that RdSAP attributes to walls within each band.

Table 17. Extract from Table S6, RdSAP 2012 v9.93, showing dwelling age band, and corresponding U Value of walls. BRE Appendix S, December 2017. Source: BRE Appendix S, December 2017

Table S6 : Wall U-values – England and Wales

Age band	A	B	C	D	E	F	G	H	I	J	K	L
Wall type												
Stone: granite or whinstone as built	a	a	a	a	1.7 b	1.0	0.60	0.60	0.45	0.35	0.30	0.28
Stone: sandstone or limestone as built	a	a	a	a	1.7 b	1.0	0.60	0.60	0.45	0.35	0.30	0.28
Solid brick as built	1.7	1.7	1.7	1.7	1.7	1.0	0.60	0.60	0.45	0.35	0.30	0.28
Stone/solid brick with 50 mm external or internal insulation	0.55	0.55	0.55	0.55	0.55	0.45*	0.35*	0.35*	0.30*	0.25*	0.21*	0.21*
Stone/solid brick with 100 mm external or internal insulation	0.32	0.32	0.32	0.32	0.32	0.28*	0.24*	0.24*	0.21*	0.19*	0.17*	0.16*
Stone/solid brick with 150 mm external or internal insulation	0.23	0.23	0.23	0.23	0.23	0.21*	0.18*	0.18*	0.17*	0.15*	0.14*	0.14*
Stone/solid brick with 200 mm external or internal insulation	0.18	0.18	0.18	0.18	0.18	0.17*	0.15*	0.15*	0.14*	0.13*	0.12*	0.12*
Cob (as built)	0.80	0.80	0.80	0.80	0.80	0.80	0.60	0.60	0.45	0.35	0.30	0.28
Cob with 50 mm external or internal insulation	0.40	0.40	0.40	0.40	0.40	0.40	0.35*	0.35*	0.30*	0.25*	0.21*	0.21*
Cob with 100 mm external or internal insulation	0.26	0.26	0.26	0.26	0.26	0.26	0.24*	0.24*	0.21*	0.19*	0.17*	0.16*
Cob with 150 mm external or internal insulation	0.20	0.20	0.20	0.20	0.20	0.20	0.18*	0.18*	0.17*	0.15*	0.14*	0.14*
Cob with 200 mm external or internal insulation	0.16	0.16	0.16	0.16	0.16	0.16	0.15*	0.15*	0.14*	0.13*	0.12*	0.12*
Cavity as built	1.5	1.5	1.5	1.5	1.5	1.0	0.60	0.60	0.45	0.35	0.30	0.28
Unfilled cavity with 50 mm external or internal insulation	0.53	0.53	0.53	0.53	0.53	0.45	0.35*	0.35*	0.30*	0.25*	0.21*	0.21*
Unfilled cavity with 100 mm external or internal insulation	0.32	0.32	0.32	0.32	0.32	0.30	0.24*	0.24*	0.21*	0.19*	0.17*	0.16*
Unfilled cavity with 150 mm external or internal insulation	0.23	0.23	0.23	0.23	0.23	0.21	0.18*	0.18*	0.17*	0.15*	0.14*	0.14*
Unfilled cavity with 200 mm external or internal insulation	0.18	0.18	0.18	0.18	0.18	0.17*	0.15*	0.15*	0.14*	0.13*	0.12*	0.12*
Filled cavity	0.7	0.7	0.7	0.7	0.7	0.40	0.35	0.35	0.45†	0.35†	0.30†	0.28†
Filled cavity with 50 mm external or internal insulation	0.37	0.37	0.37	0.37	0.37	0.27	0.25*	0.25*	0.25*	0.25*	0.21*	0.21*
Filled cavity with 100 mm external or internal insulation	0.25	0.25	0.25	0.25	0.25	0.20	0.19*	0.19*	0.19*	0.19*	0.17*	0.16*

Table 18. Table S1, RdSAP 2012 v9.93, showing dwelling age bands A-L and their corresponding year groups. For reference with Table S6 above. Source: BRE Appendix S, December 2017.

Table S1 : Age bands

	Years of construction			
Age band	**England & Wales**	**Scotland**	**Northern Ireland**	**Park home (UK)**
A	before 1900	before 1919	before 1919	-
B	1900-1929	1919-1929	1919-1929	-
C	1930-1949	1930-1949	1930-1949	-
D	1950-1966	1950-1964	1950-1973	-
E	1967-1975	1965-1975	1974-1977	-
F	1976-1982	1976-1983	1978-1985	before 1983
G	1983-1990	1984-1991	1986-1991	1983-1995
H	1991-1995	1992-1998	1992-1999	(not applicable)
I	1996-2002	1999-2002	2000-2006	1996-2005
J	2003-2006	2003-2007	(not applicable)	(not applicable)
K	2007-2011	2008-2011	2007-2013	2006 onwards
L	2012 onwards	2012 onwards	2014 onwards	(not applicable)

Prior to 1900, RdSAP does not record separate age bands, but relies instead on an accurate wall thickness and material being inputted. The procedure for calculating the value is therefore more heavily reliant on the accuracy of the wall thickness measurement. The calculation for this is below:

Table 19. S5.1.1 RdSAP 2012 v9.93, showing U value calculation method for solid stone walls within age bands A-E. Source: BRE Appendix S, December 2017.

S5.1.1 U-values of uninsulated stone walls, age bands A to E

Granite or whinstone: $U = 3.3 - 0.002 \times$ thickness of wall in mm
Sandstone or limestone: $U = 3.0 - 0.002 \times$ thickness of wall in mm

The U Value for solid walls has recently been revised to reflect a greater level of efficiency than had previously been thought, following submission of evidence from a study commissioned by DECC and subsequent consultation (Davidson, 2016). The figure of 1.7 recorded in Table 19 spans across all non-stone solid wall types pre-1900 and applies also to non-stone solid walls constructed up to and including RdSAP year band E (1967-1975). In addition, as can be seen from Table 19 above, the method for calculating the U Value of stone walls is – while not fixed, is heavily prescribed, and the wall thickness (the only variable the DEA has control over) must be markedly different to yield any significant influence on the result. In these circumstances, it may be reasonable to assert that there is less scope for variation, and an inaccurate assessment of the build date may be seen as less problematic. Notwithstanding the reduced potential for variability here, the control property was constructed during the 1700's, and so a cushion for an inaccurate assessment of the build date was large, which may have assisted all ten of the DEAs in identifying this correctly, as can be seen in Table 20 below.

Table 20. Showing wall age, type and thickness of both the main dwelling and extension. Study strand 1, phase 2.

	Year of Construction (main)	Construction (extn)	Main wall (type)	Main wall thickness (mm)	Extension wall (type)	Extn. wall thickness (mm)
CONTROL	Pre 1900	1950 - 1966	Solid sandstone (as built)	480	Masonry cavity (as built)	350
DEA 1	Pre 1900	1950 - 1966	Solid sandstone (as built)	500	Masonry cavity (as built)	360
DEA 2	Pre 1900	1950 - 1966	Solid sandstone (as built)	450	Solid brick (as built)	N/K
DEA 3	Pre 1900	1950 - 1966	Solid sandstone (as built)	480	Masonry cavity (as built)	350
DEA 4	Pre 1900	1950 - 1966	Solid sandstone (as built)	500	Masonry cavity (as built)	330
DEA 5	Pre 1900	1950 - 1966	Solid sandstone (as built)	570	Masonry cavity (as built)	300
DEA 6	Pre 1900	1950 - 1966	Solid sandstone (as built)	500	Masonry cavity (as built)	360
DEA 7	Pre 1900	1950 - 1966	Solid sandstone (as built)	500	Masonry cavity (as built)	320
DEA 8	Pre 1900	1950 - 1966	Solid sandstone (as built)	480	Masonry cavity (as built)	360
DEA 9	Pre 1900	1950 - 1966	Solid sandstone (as built)	480	Masonry cavity (as built)	300
DEA 10	Pre 1900	1991 - 1995	Solid sandstone (as built)	420	Masonry cavity (as built)	320

The extension to the rear does not possess an abundance of architectural features, and as it is rendered; the materials used to build it are not visible. It may be reasonable to argue that in these circumstances, an accurate assessment of its date of construction is quite challenging. The researcher had documentary evidence of the build date of the extension, which was 1965, from the local planning authority, although he did not share this with the DEAs. Despite this, nine out of the ten DEAs estimated the extension date correctly, with band 1950-1966 being selected. DEA 10's estimate of year band 1991-1995 will have had an impact on the RdSAP score, improving it, as the U Value of walls constructed during this period defaults to 0.6, as can be seen in Table 15. This is less than half the default of 1.5 attributed to the same cavity constructed extension walls with the correct build date band of 1950-1966, age band D.

DEA 2 elected to record the extension walls as solid walls: an interesting choice as they correctly recorded the build date, but did not link this with the likelihood that walls of residential buildings constructed in England during this period contain cavities, almost without exception. This may highlight gaps in the knowledge of this DEA, which lead them to the incorrect assumption that the extension wall structure type matched that of the original dwelling. This assumption would actually have made very little difference though: the default for solid walls in age band D 1950-1966 is 1.7, where for cavity constructed walls of the same age it is 1.5, marking a detriment of just 0.2 W/m^2K (watts per square meter per degree centigrade, or kelvin: the unit of measurement for U Values).

Notwithstanding the discrepancies over wall thickness, it may be reasonable to assert that walls at the control property were recorded with a fairly high level of accuracy, certainly in comparison with the inputs of other dwelling components discussed in this section.

This concludes the discussions surrounding the first test property and its EPC data. Section 5.6 which follows will move on to the second test property.

5.6 STRAND 2 PHASE 2: THE SECOND TEST EPC

5.6.1 Introduction

In the first phase of Strand 2, a control EPC was selected to form part of a site-based study, which, consistent with the exploratory sequential design methodology selected (Sauro, 2015) was informed by the Strand 1 DEA interviews. At the very start of the Strand 2 exercise, there was some ambiguity over whether one, or two site-based EPCs would be carried out, with all twenty, or ten DEAs (at each property) respectively. This was intentional, as a review of the situation, where a decision either way could be made without detriment to the overall study aim, was scheduled at a later stage. It became clear shortly after the outset of this second phase of study that despite the additional number of DEAs, and the hence improved statistical reliability that may be afforded to undertaking a single EPC, analysis of the results of a single EPC would not be as robust as analysis of two EPCs, undertaken by ten DEAs at each. This is for two reasons. Firstly, it was always acknowledged that a greater breadth of dwelling attributes could be covered if more than one property was selected, but there would be a simple tradeoff between the benefit of this, set against the fewer DEAs looking at each dwelling. But secondly, and more importantly, it came to light that not only a different, but a simpler building should be selected, so that not only differing building attributes could be scrutinised, but a less complex building overall could be appraised. This would give some balance to the Strand 2 study overall, because the first test property selected was a more complex dwelling than originally anticipated. A discussion about the complexity of test property 1, and how this was not fully understood at the outset is given later in this chapter. Fortunately, with an early appraisal of the situation, always scheduled at a point soon after the start on site of work on test property 1 (after the control was complete, but before any DEAs had begun their appraisals), this unexpected extra complexity was acknowledged, and a decision to split the Strand 2 exercise into two parts - or two properties, was made.

5.6.2 Test property 2 respondent selection

After revising the necessary ethical approvals from phase one of Strand 2, including resubmitting these to the university and obtaining supervisor approval (see Appendix C), the remaining ten of the DEAs who took part in the interviews, and who did not take part in the first test EPC were approached first: they were contacted in the same way as earlier stages, via telephone, email, or both, and two bookings were made this way to have EPCs carried out at the second test property. Interestingly, four of the ten DEAs responded only to confirm that they were no longer undertaking EPCs and were no longer assigned to an accrediting body. They declined to take part on this basis. After having booked only two appointments for EPCs on a ‘first come, first served’ basis from the remainder of the twenty DEAs that took part in the interviews, the ten DEAs who took part in the first test EPC were approached again. Six of these DEAs offered to take part for a second time. Finally, for the remaining two EPCs, the same approach was taken at the very start of Strand 1, where a pool of 46 DEAs were contacted (see Section 4.1.1 p146). This gleaned more than two responses, again (as before) from DEAs who had experience of producing EPCs for a variety of different purposes, and two DEAs were selected on a first come, first served basis. These two DEAs were not known to the researcher and had not taken part in the interviews or the first test property. The total of 10 DEAs taking part in this second phase of Strand 2 were selected this way.

5.6.3 Respondent procurement and schedule

This second tranche of ten EPCs were undertaken during a four-month period, from 13th February 2019 to the 12th June 2019. Each was booked at least three working days in advance after making telephone or emailed appointments, as discussed in the introduction above, and in the same way as the more detailed introduction to Chapter 6. Each DEA was paid a rate consistent with the current market for procuring EPCs: a fee of £50 (+VAT where applicable), as was the case for the first test property, and each DEA signed the consent forms, consistent with the University's ethical approval procedure. In the interests of transparency, the payments were made by the researcher, to the DEA. The ethical approval submission, approved by the University, is included in Appendix C of this reserach, as are the participant information and participant consent forms (Appendices D and E). The individually signed consent forms, along with records of individual payments, and email exchanges answering respondent's queries about the research prior to giving consent are all available upon request, but not included in this thesis.

The researcher completed an 11th, 'control' EPC at the property, taking site notes and photos at the start of the process, on the 9th February 2019 and lodging the EPC (recording it officially with the land registry) on the 11th February 2019. This was completed to the best of the researcher's ability, and then also submitted to the researcher's accrediting body, Elmhurst, for independent audit. The reason for this was to bring as much legitimacy to this control EPC as possible. While variability may be established without a control, the extent of variability and any discussion about a margin of error would be more challenging to establish without a baseline. A control, while noted as fallible - and consequently a limitation - provides a benchmark against which to appraise other EPCs.

Each EPC commission was the same in scope as would be for any regular EPC instruction, the only difference being that each DEA would record the data on a paper form, for the researcher to input and formally lodge on his DEA account with the land registry. The data was inputted by the researcher into his own account rather than having DEAs input the data into their respective accounts, so the researcher would have unimpeded access to each DEA's inputs and accompanying 'xml' data - the data in its raw form - feeding the RdSAP calculator. The paper forms and site notes have been retained by the researcher, and are available upon request, but are quite extensive and therefore not included in the appendices of this thesis.

Each DEA carried out the EPC by inspecting the property externally first, then from within, non-intrusively, with use of surveyor's ladders, a torch, a laser and tape measure, and a camera. Five DEAs were noted to use the site notes recommended by their Accrediting Body, which the researcher had encouraged (to aid data entry) while five DEAs used their own site templates, which they said they felt more comfortable with. DEAs were timed by the researcher. Notwithstanding opening introductions and a brief recap of the study purpose, the inspection process itself was noted to take from 30 minutes, to 55 minutes. This is notably less than the time taken to produce the first test property EPC, which may be no surprise given the less complex nature of the second test property. The time it took to complete the site survey seemed to bear no clear relation to EPC variation.

After the inspection was completed, none of the DEAs handed forms directly back to the researcher, despite this being an option for them. Instead, each requested a short period to reflect and digest their site notes prior to finalising their submission. One DEA sought advice from the researcher about compartmentalising an integral garage. The researcher explained he could not assist with this and it must be the DEA's own work. He indicated he may seek advice from the technical department of his accrediting body prior to completing the EPC as an alternative. It is possible that without the Hawthorne effect and in a regular working environment, DEAs may have entered data directly onto their site notes or into the RdSAP model and produced an EPC. This would have seen the commission 'off the desk' for DEAs and could have lead to more erroneous data finding its way onto the finalised EPC. However, this is conjecture, and the behaviour of DEAs within the study conditions has been marked already as a limitation.

The ten DEAs taking part in the second tranche of EPCs were professionally and academically experienced as follows:

Table 21. Showing the professional and academic experience of the sample set of DEAs taking part in tranche 2 of the EPC site based study.

Site based EPC study: EPC 2					
DEA	Job title	Background	Academic qualifications	Professional qualifications	Years' experience
1	DEA/Local Authority search provider	Conveyancing/Energy surveying	No relevent FE/HE	Qualified DEA/OCDEA	> 15 years related
2	Housing stock condition surveyor	Building Surveying	Relevant Degree	Qualified DEA	> 20 years related
3	Technical monitoring officer	Insulation/Energy Surveying	No relevent FE/HE	Qualified DEA/OCDEA	> 15 years related
4	Valuation surveyor	Social housing	No relevent FE/HE	Qualified DEA	> 5 years related
5	Valuation surveyor	Social housing	Currently in related FE	Qualified DEA	> 5 years related
6	New build acquisitions manager	Social housing	Relevant Masters	Qualified DEA	> 5 years related
7	Housing surveyor	Housing stock condition surveying	Relevant Masters	Qualified DEA/OCDEA	> 20 years related
8	Architectural technician	Land surveying / autoCAD technician	Relevant HND level	Qualified DEA	> 20 years related
9	DEA/Green Deal Advisor	Energy assessor	No relevent FE/HE	Qualified DEA	> 15 years related
10	DEA/Local Authority search provider	Conveyancing/Energy surveying	No relevent FE/HE	Qualified DEA/Commercial DEA	> 10 years related

Table 21 shows that all 10 DEAs had built environment related occupations, but that only one of them actually described themself as a DEA specifically. So, while only one DEA produced EPCs on a full-time basis, most of the remaining 9 DEAs would produce EPCs as an essential part of their role, with the exception of DEAs 6 and 8. These two both took part in the first test EPC and had needed to be DEAs for previous roles. As with the first test EPC, all 10 of these DEAs had more than five years' built environment related experience (though in a wide range of disciplines) and all had been qualified as a DEA for over five years also. It was not the researcher's intention to locate DEAs with many years of experience: this came to light after the DEA's services had been procured. This should be recorded as a limitation, and newly qualified/more recently qualified DEAs may have produced different EPCs to those analysed within this study. However, the number of EPCs the DEAs had produced varied considerably, from the high tens in the case of DEA 8, to the hundreds, and in more than half the cases, thousands of completed EPCs. This might be seen as an equally reliable indicator, and a better spread of experience than the number of years that expired since qualifying.

5.6.4 Test property 2 selection and characteristics

At the point of considering what sort of property to select for this second phase of study, the twenty interviews in strand 1 were complete, interview material had been analysed and presented in a draft journal paper, and the control for the first site-based EPC of phase 1, strand 2, was complete. The phenomenon of variability was established anecdotally at this stage, and while the decision to split the second phase into two was made at this point, the decision about which property to choose for a second phase could be put on hold a while longer, while the outputs of the first EPC were collated, at least in brief. This may be seen as a useful facet of the sequential methodological approach – the ability to take time and process existing data before moving on. In this case, the opportunity took the researcher to a stage where variability was found to exist. The extent of variability was greater than the researcher anticipated, as discussed in Chapter 6, and this was attributed in part to the complexity of the test property selected for the first site-based EPC. So, in selecting a property for the second phase of the EPC site study, a number of desirable attributes were established. These may be summarised as follows:

- Property 2 should be a more straightforward proposition than Property 1. This would help to give some balance to the complexity of Property 1 and show how variability may itself vary when less complex dwellings are assessed by DEAs. To be more precise, straightforward in this context would mean a simpler property with, for example, no alterations post-construction, the same wall type, heating system, loft type, throughout, if possible.
- Property 2 would ideally have a loft. Property 1 had part vaulted ceiling (where an average is taken to appraise ceiling height for dwelling geometry) and part flat roof. In both cases there was no access to the roof structure itself to appraise the level of insulation. At Property 2, a measurement of the thickness of insulation from within the loft space would be desirable, because this was a dwelling attribute that was unable to be tested in Property 1.
- Property 2 would be traditionally constructed, like Property 1. The same justification is given here as was for Property 1: it best represents the UK's housing stock. There is more discussion about this later, but to summarise, presenting DEAs with a non-traditionally constructed property would not be representative of a 'typical' UK EPC due to the very small proportion of the total UK housing stock that they constitute, and there would be an argument that any

variability may be attributed to the uniqueness of the dwelling type, which is not the intended purpose here. In this case, ideally the property would be constructed in a different way to Property 1, but in a 'traditional' manner, so that an additional dwelling component could be tested, but in a simpler way than before. The property selected had a timber frame but was constructed using traditional materials and techniques.

- The dwelling archetype would be representative of the UK housing stock. Terraced houses constitute the largest single proportion of housing stock in the UK: 7.74 million homes are terraced (Palmer & Cooper, 2013). This time, a mid terrace property would be targeted, rather than an end terrace, (which may equally be construed as a semi detached) as was the case with Property 1.
- Having appraised a much older property during the first phase of this site-based exercise, in the interests of balancing the overall set of dwelling attributes, this property would be a more modern build.
- The property should be more straightforward to address for the DEA than Property 1, but still present a small number of challenges. In this case, the property had an integral garage and a conservatory.

To summarise, the property selected was a 2000 constructed three-bedroom mid terrace 'townhouse', constructed with a timber frame within brick outer facing walls, under a pitched, slate covered roof. The property had not been extended, altered or reconfigured from the original design. The property measured 150 square meters: arguably a little above average size for this type of property and was heated with gas fired central heating via a combination boiler, feeding radiators to each room. The property was double glazed throughout, with the original frames. In the interests of transparency, it should be noted that this was the researcher's own home. This was convenient in respect to arranging appointments and scrutinising submitted EPC data (with the subject property available to revert back to whenever necessary), but also in terms of the intimate knowledge the researcher had of the property, which may be considered useful in adding some degree of credence to the quality of the control EPC (though by no means conclusive and noted for the record as fallible).

Photographs of the front and rear elevations of the property are presented below, followed by photographs of key dwelling attributes below this. The complete photo set is included in Appendix L.

Image 1. Front elevation of control property for phase 2 of the EPC site study, showing integral garage.

Image 2. Rear elevation of control property for phase 2 of the EPC study, showing conservatory, which is open to the main dwelling, and therefore considered a part of the dwelling

Image 3. A wider view of the loft insulation, showing a consistent, relatively even level throughout. Note also here the view of the party wall, with the grey plastic sheet over it. It can be hard to identify the

existence of a timber frame in place of a cavity constructed house (with use of brick and block, as opposed to brick and timber frame), because externally the two are very similar in appearance, but a loft can be a useful place to establish this. The loft of a brick and block, cavity constructed house would have blockwork party walls dividing the house from its neighbour, and these would be clearly visible. Here, the plastic sheet would raise suspicion for the experienced DEA – why is there no visible blockwork, and what sort of construction method would involve lining the party wall with a plastic membrane like this?

Images 4 & 5. A boiler with a thermal store: essentially a combination boiler, located in the airing cupboard off the second (top) floor landing. Make and model, along with model 'qualifier' (the specific model type) are clearly identifiable on the front panel of the boiler below.

5.6.5 Test property 2 control EPC

The photographs in the section above and in Appendix M show the key energy efficient components of the property selected for the second half of the site-based EPC study. To summarise in brief, this is a circa year 2000, traditionally constructed timber framed three-bedroom mid terrace house with a conservatory to the rear and an integral garage, gas central heating, double glazing and 200mm of loft insulation. There are no extensions, alterations or additions: the dwelling is 'as built' and may be seen as a straightforward proposition for the DEA in terms of production of an EPC.

The control EPC was completed by the researcher on site on the 9th February 2019, before any of the study EPCs were undertaken. The work on site consisted of drawing up carefully measured floor plans, filling out site notes, and taking photographs. The inspection required the use of a torch, camera, and surveyor's (2.8m telescopic) ladders. The inspection took 40 minutes, but this did not include entering the data into the RdSAP model to produce the EPC itself. This was completed two days later and took a further forty minutes. The whole operation took one hour and twenty minutes in total. This may be seen as a typical timeframe for completion of an EPC, which two interview respondents in Strand 1 verified, suggesting it took them typically between one and two hours inclusive, depending on the complexity of the building. The researcher was keen to ensure the quality of the EPC was high and no erroneous data was included, and so while a straightforward property such as Property 2 may usually have taken the lower end of this time frame – circa an hour, the researcher was keen to ensure all data was double checked, before lodging the EPC. The researcher contacted the accrediting body with whom he is registered, Elmhurst, and requested that this control EPC be audited. As discussed in Chapter 4, this may be considered quite an unusual request, but having explained the purpose of the research to Elmhurst for a second time, following on from Phase 1, and sending them the participant information form for information (see Appendix E), they agreed to audit the EPC on request in this instance. The reason for requesting an audit was the additional credence, or robustness this would add to the control's legitimacy. As noted earlier, in the study by Jenkins (Jenkins et al., 2017) no audit was undertaken on the control EPCs, and while this would provide a useful benchmark by which to measure variation anyway, it would not preclude the possibility of errors being contained within the control. There is never a guarantee that the EPC is free from errors, and indeed many of the DEAs made assertions about the fallibility of the audit process within their interviews – the checks undertaken by the Accrediting Body, especially where no pressure is brought to bear and the researcher is making best endeavours to generate an accurate report, may be seen as increasing the level of authenticity.

After lodging the EPC and submitting it for audit on February 11th 2019, the researcher was contacted by Elmhurst's audit department on the 21st February 2019 to confirm the EPC had passed audit, meeting the necessary requirements. A screen shot of this confirmation email is submitted in Appendix I. In the confirmation email was an 'advisory' paragraph, suggesting dwelling heat loss perimeter (the perimeter of the building exposed to the outside air) was inaccurately recorded. The suggestion was that the ground floor exposed perimeter of the building should be 5.12m. The perimeter of the integral garage had been included in the researcher's calculations, but rightly so, consistent with the extract from RdSAP Appendix S, below:

RdSAP 2012 version 9.93 (19 November 2017)

> The measurements required are the floor area, exposed perimeter, party wall length and room height on each storey. Exposed perimeter includes the wall between the dwelling and an unheated garage or a separated conservatory and, in the case of a flat or maisonette, the wall between the dwelling and an unheated corridor.
>
> Internal dimensions are permissible in all cases. In the case of a house or bungalow external dimensions for area and perimeter are usually more convenient, except where access to all sides of the building is not possible or where there are differing wall thicknesses or other aspects that would make the dimensional conversion unreliable. When using external measurements for a dwelling joined onto another dwelling (semi-detached and terraced houses) the measurement is to the mid-point of the party wall. Flats and maisonettes are usually measured internally (although it is not a requirement of the specification that internal measurements are always used and if measured externally the measurement is to the mid-point of the party wall). Whichever is chosen the same basis must be used for all parts of the dwelling. Party wall length uses the same basis as exposed perimeter.
>
> Room heights are always measured internally within the room.

Figure 31. Extract from RdSAP Appendix S, 2012 v9.93, explaining what is included when calculating the exposed perimeter, or 'heat loss perimeter'. Source: RdSAP Appendix S, BRE, 2017

The researcher's floor plan, submitted for review shows the exposed heat loss perimeter of the building, including the walls facing the integral garage at ground floor level. This is noted with supporting information at the end of this chapter. The recommendation to discount this by the Elmhurst Auditor was incorrect and would have lead to an inaccurate

EPC with an RdSAP rating, as recorded by the auditors themselves, of +1 over the submitted RdSAP rating. While not seen as such a severe infringement of the rules as to fail audit, the advice is nonetheless incorrect, and could have led to the DEA making errors in future EPCs. The researcher followed up on this, but without comment from the auditing department. This may have been a simple misunderstanding of the site notes, or more worryingly of the conventions, but no firm conclusions can be drawn without feedback from the auditors. This feedback is in contrast to the diligent feedback given after the first, more complex EPC was submitted for audit, where auditors correctly identified an inaccuracy, and the EPC had to be re-submitted by the researcher for audit.

The four-page EPC for this second test property is displayed over the following pages.

Energy Performance Certificate

HM Government

11, Grosvenor Park, YORK, YO30 6BX

Dwelling type:	Mid-terrace house	**Reference number:**	0618-9041-7292-5331-7944
Date of assessment:	09 February 2019	**Type of assessment:**	RdSAP, existing dwelling
Date of certificate:	11 February 2019	**Total floor area:**	153 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

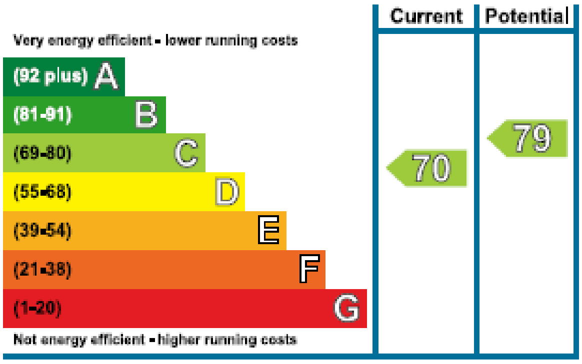
Estimated energy costs of dwelling for 3 years:	**£ 3,357**
Over 3 years you could save	**£ 276**

Estimated energy costs of this home

	Current costs	Potential costs	Potential future savings
Lighting	£ 447 over 3 years	£ 258 over 3 years	You could save £ 276 over 3 years
Heating	£ 2,571 over 3 years	£ 2,394 over 3 years	
Hot Water	£ 339 over 3 years	£ 429 over 3 years	
Totals	£ 3,357	£ 3,081	

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.

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

Recommended measures	Indicative cost	Typical savings over 3 years
1 Low energy lighting for all fixed outlets	£80	£ 168
2 Replace heating unit with condensing unit	£2,200 - £3,000	£ 111
3 Solar photovoltaic panels, 2.5 kWp	£5,000 - £8,000	£ 876

To find out more about the recommended measures and other actions you could take today to save money, visit www.gov.uk/energy-grants-calculator or call **0300 123 1234** (standard national rate). The Green Deal may enable you to make your home warmer and cheaper to run.

Above: Property 2, Control EPC Page 1. Below: Property 2, Control EPC Page 2.

Summary of this home's energy performance related features

Element	Description	Energy Efficiency
Walls	Timber frame, as built, insulated (assumed)	★★★★☆
Roof	Pitched, 200 mm loft insulation	★★★★☆
Floor	Solid, limited insulation (assumed)	—
	To unheated space, limited insulation (assumed)	—
Windows	Fully double glazed	★★★☆☆
Main heating	Boiler and radiators, mains gas	★★★★☆
Main heating controls	Programmer, room thermostat and TRVs	★★★★☆
Secondary heating	None	—
Hot water	From main system	★★★★☆
Lighting	Low energy lighting in 27% of fixed outlets	★★★☆☆

Current primary energy use per square metre of floor area: 195 kWh/m² per year

The assessment does not take into consideration the physical condition of any element. 'Assumed' means that the insulation could not be inspected and an assumption has been made in the methodology based on age and type of construction.

Low and zero carbon energy sources

Low and zero carbon energy sources are sources of energy that release either very little or no carbon dioxide into the atmosphere when they are used. Installing these sources may help reduce energy bills as well as cutting carbon. There are none provided for this home.

Your home's heat demand

For most homes, the vast majority of energy costs derive from heating the home. Where applicable, this table shows the energy that could be saved in this property by insulating the loft and walls, based on typical energy use (shown within brackets as it is a reduction in energy use).

Heat demand	Existing dwelling	Impact of loft insulation	Impact of cavity wall insulation	Impact of solid wall insulation
Space heating (kWh per year)	15,538	N/A	N/A	N/A
Water heating (kWh per year)	2,358			

You could receive Renewable Heat Incentive (RHI) payments and help reduce carbon emissions by replacing your existing heating system with one that generates renewable heat, subject to meeting minimum energy efficiency requirements. The estimated energy required for space and water heating will form the basis of the payments. For more information, search for the domestic RHI on the www.gov.uk website.

Recommendations

The measures below will improve the energy performance of your dwelling. The performance ratings after improvements listed below are cumulative; that is, they assume the improvements have been installed in the order that they appear in the table. Further information about the recommended measures and other simple actions you could take today to save money is available at www.gov.uk/energy-grants-calculator. Before installing measures, you should make sure you have secured the appropriate permissions, where necessary. Such permissions might include permission from your landlord (if you are a tenant) or approval under Building Regulations for certain types of work.

Recommended measures	Indicative cost	Typical savings per year	Rating after improvement
Low energy lighting for all fixed outlets	£80	£ 56	C71
Replace heating unit with condensing unit	£2,200 - £3,000	£ 37	C72
Solar photovoltaic panels, 2.5 kWp	£5,000 - £8,000	£ 292	C79

Alternative measures

There are alternative measures below which you could also consider for your home.

- Micro CHP

Opportunity to benefit from a Green Deal on this property

Green Deal Finance allows you to pay for some of the cost of your improvements in instalments under a Green Deal Plan (note that this is a credit agreement, but with instalments being added to the electricity bill for the property). The availability of a Green Deal Plan will depend upon your financial circumstances. There is a limit to how much Green Deal Finance can be used, which is determined by how much energy the improvements are estimated to **save** for a 'typical household'.

You may be able to obtain support towards repairs or replacements of heating systems and/or basic insulation measures, if you are in receipt of qualifying benefits or tax credits. To learn more about this scheme and the rules about eligibility, call the Energy Saving Advice Service on **0300 123 1234** for England and Wales.

Property 2, Control EPC Page 3

About this document and the data in it

This document has been produced following an energy assessment undertaken by a qualified Energy Assessor, accredited by Elmhurst Energy Systems Ltd. You can obtain contact details of the Accreditation Scheme at www.elmhurstenergy.co.uk.

A copy of this certificate has been lodged on a national register as a requirement under the Energy Performance of Buildings Regulations 2012 as amended. It will be made available via the online search function at www.epcregister.com. The certificate (including the building address) and other data about the building collected during the energy assessment but not shown on the certificate, for instance heating system data, will be made publicly available at www.opendatacommunities.org.

This certificate and other data about the building may be shared with other bodies (including government departments and enforcement agencies) for research, statistical and enforcement purposes. Any personal data it contains will be processed in accordance with the General Data Protection Regulation and all applicable laws and regulations relating to the processing of personal data and privacy. For further information about this and how data about the property are used, please visit www.epcregister.com. To opt out of having information about your building made publicly available, please visit www.epcregister.com/optout.

Assessor's accreditation number:	EES/006272
Assessor's name:	Mr. Toby Gledhill
Phone number:	01924 249970
E-mail address:	toby@w-y-p.co.uk
Related party disclosure:	Residing at the property

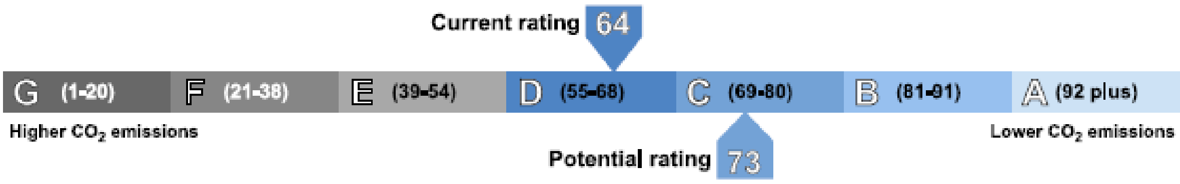
There is more information in the guidance document *Energy Performance Certificates for the marketing, sale and let of dwellings* available on the Government website at: www.gov.uk/government/collections/energy-performance-certificates. It explains the content and use of this document, advises on how to identify the authenticity of a certificate and how to make a complaint.

About the impact of buildings on the environment

One of the biggest contributors to global warming is carbon dioxide. The energy we use for heating, lighting and power in homes produces over a quarter of the UK's carbon dioxide emissions.

The average household causes about 6 tonnes of carbon dioxide every year. Based on this assessment, your home currently produces approximately 5.2 tonnes of carbon dioxide every year. Adopting the recommendations in this report can reduce emissions and protect the environment. If you were to install these recommendations you could reduce this amount by 1.2 tonnes per year. You could reduce emissions even more by switching to renewable energy sources.

The environmental impact rating is a measure of a home's impact on the environment in terms of carbon dioxide (CO_2) emissions based on standardised assumptions about occupancy and energy use. The higher the rating the less impact it has on the environment.



Property 2, Control EPC Page 4

5.7 TEST EPC 2 RESULTS

5.7.1 Property 2 EPC analysis

The control EPC, displayed in full above, recorded the property's RdSAP rating as Band C 70. This is displayed on the first page of the certificate: see the control EPC, laid out in Section 7.1 directly prior to this section. This began the analysis for EPC 1, and may be seen as the 'headline' figure, and a suitable place to start with the analysis of EPC 2. So to begin with, the ten test EPCs may be compared against this control, using just their RdSAP ratings. The table below shows the control EPC's RdSAP rating and score, along with those of the EPCs carried out by the DEAs in phase 2 of the Quantitative strand 2 study.

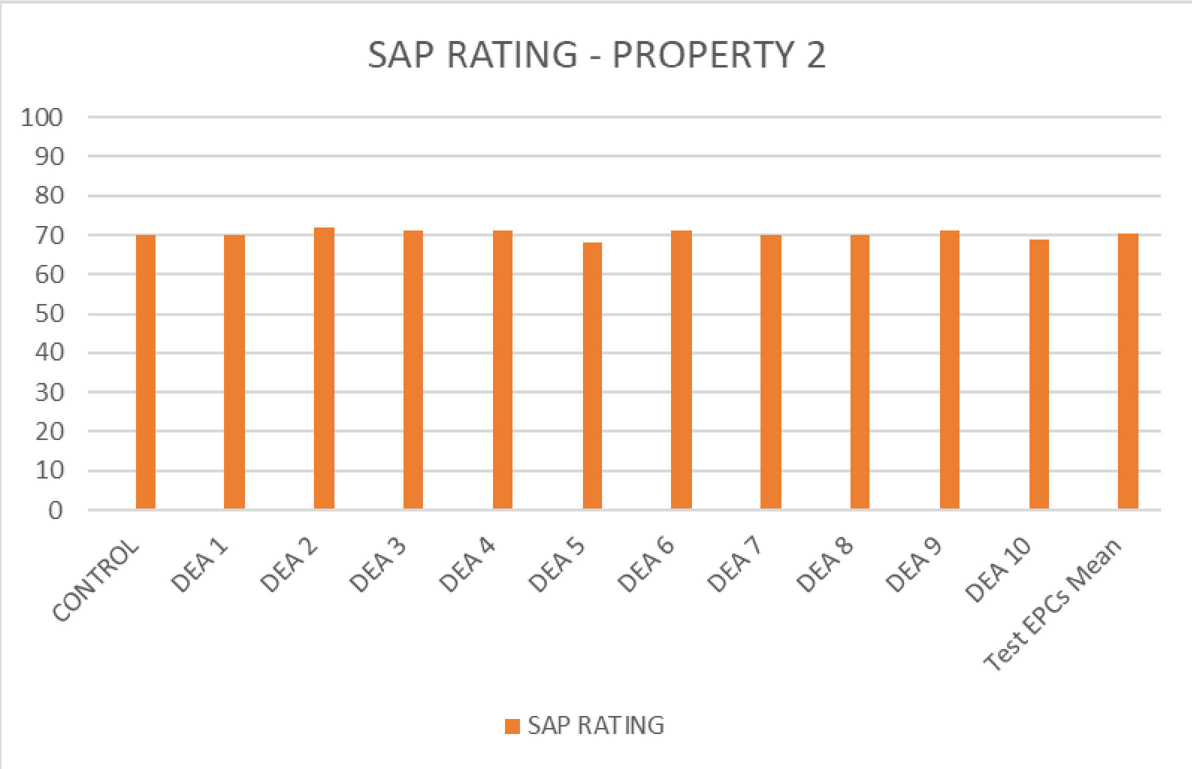
Table 22. RdSAP ratings and scores for test EPC 2, including overall mean and standard deviation for test EPCs only. Quantitative study research strand 2

	SAP BAND	SAP RATING
CONTROL	C	70
DEA 1	C	70
DEA 2	C	72
DEA 3	C	71
DEA 4	C	71
DEA 5	D	68
DEA 6	C	71
DEA 7	C	70
DEA 8	C	70
DEA 9	C	71
DEA 10	C	69
Test EPCs Mean	C	70.3
Test EPCs Standard Deviation	1.14	

Restricting analysis at the outset to just the RdSAP ratings above, the test EPC was attributed a rating spanning two RdSAP bands, and 4 SAP points across the eleven EPCs.

There are seven bands on the RdSAP scale: A to G, and SAP scores span from 1 to 100. To show this in a different context, the results for this one property may be seen within the entire SAP scale of 1 to 100 in bar form below.

Table 23. RdSAP scores for test EPC 2. Quantitative study research strand 2



It is clear from early observation that these EPCs are very consistent with one another. Only DEA 5's EPC sits in the RdSAP band below that of the control, and even this scored 68; at the top of Band D. DEA 10's EPC scored 69, and sat in Band C, along with all the others. DEA 2's EPC scored the highest rating with 72, though this still falls well within Band C, with Band B starting at a score of 81.

While four SAP points, from the DEA 2's highest, to DEA 5's lowest, may be seen as a notable margin with potentially significant implications, eight of the test EPCs at this property were within two SAP points of the control. This is in a context where +/- 1 SAP point is considered a tolerable margin of error by accrediting bodies, such that – as with the audited control property here – an error of this size would not fail an audit, and would fall within the margin of error government guidance requires (of +/-5 SAP points at 95% of EPCs)(DCLG, 2011).

During interviews, the defaulting ‘rounding down’ of RdSAP where there is limited information, or information is missing altogether, was criticised. This is noted earlier in this chapter and was borne out in the results of test EPC 1, but analysis of test EPC 2’s data here adds an interesting dimension to the discussion. As noted in earlier in this chapter, Stone, Shipworth et al., (2014) undertook a study into the key building components that influence RdSAP variance. To recap briefly, their study was a desk-based exercise, analysing existing English Housing Survey (EHS) data by converting it back into RdSAP inputs and modelling the inputs using Monte Carlo samples, then analysing the distribution. To summarise (this explanation is also given earlier in more detail) with these results, they produced sensitivity analyses for each building component which may influence energy efficiency and ordered these by the extent their influence can vary overall outcome. This is given again here because a) it seen as a useful study to feed into this research because, triangulated with the interview material it helps to justify a focus on key dwelling inputs, but also b) after having begun to investigate the data for EPC 2, a generic sensitivity analysis may not be appropriate when the accuracy of one EPC may be so much greater than that of another. This is discussed in more detail in Chapter 6.

As noted earlier in this chapter, the study by Stone focused on those elements which had the largest contribution to the observed variance of energy rating, based on the RdSAP section of the English Housing Survey data sets from 2009. To avoid repetition, in short, Stone found the first three dwelling attributes with the greatest potential variance were dwelling geometry, heating system efficiency, and external wall U-value (the assumed thermal efficiency of walls as a standalone component). This is consistent with the thoughts of the interviewed DEAs, who also cited geometry and heating systems as key sources of potential variation. These three components alone are shown by Stone to account for over 75% of the variance in SAP rating and Environmental Impact (EI) rating, and this, reinforced by the interview material, is used here as justification for analysing these inputs in the case study EPCs.

5.7.2 Property 2 dwelling geometry

The reference made by Stone to dwelling geometry encompasses a number of important RdSAP inputs. While geometry is related primarily to dwelling floor area, it also refers to two further key attributes: ceiling heights and heat loss perimeter. Reference is made to this in earlier so in short, the heat loss perimeter is the perimeter of the building, which is exposed to the open air, as opposed to that which is attached to other properties. Ceiling heights may be seen as equally important within dwelling geometry, because RdSAP needs to determine the volume of space being heated. Clearly, with all other things being equal, the greater the volume of space that requires heating, the higher the cost, hence the lower the RdSAP score.

Table 24 below shows the RdSAP bands, SAP scores, and dwelling geometry data for control EPC 2, and all ten test EPCs, including mean and standard deviation. The table containing the same data for the first test EPC is given again below this, for ease of comparison between the two.

Table 24 showing RdSAP bands, SAP scores, and dwelling geometry for Test EPC 2, including data for the control EPC and all ten test EPCs, as well as mean and standard deviation. Study strand 2, phase 2.

	SAP BAND	SAP RATING	Total Floor Area	Total HLP	Total Ceiling Height (Ave)	Conservatory Floor Area	Conservatory HLP
CONTROL	C	70	153	35	2.68	7.98	8.48
DEA 1	C	70	149	35.47	2.68	6.55	7.81
DEA 2	C	72	153	43.3	2.60	6.75	7.9
DEA 3	C	71	143	35.99	2.51	5.99	7.24
DEA 4	C	71	167	32.28	2.63	8.4	8.79
DEA 5	D	68	148	35.84	2.64	8.49	8.85
DEA 6	C	71	169	38.1	2.62	6.79	8.06
DEA 7	C	70	149	35.42	2.69	6.56	7.82
DEA 8	C	70	150	52.16	2.70	6.59	7.83
DEA 9	C	71	152	35.1	2.70	8.41	5.8
DEA 10	C	69	151	43.3	2.67	6.56	7.82
Test EPCs Mean	C	70.3	153.1	38.69	2.64	7.11	7.79
Test EPCs Standard Deviation	1.14		2.44	2.12	0.21	0.89	0.71

Table 25 from earlier in this chapter, shown again here for ease of reference. This table shows RdSAP bands, SAP scores, and dwelling geometry data for test EPC 1, including the control EPC and all ten test EPCs, as well as mean and standard deviation. Study strand 1, phase 2.

	SAP Band	SAP Rating	Total Internal Floor Area	Conservatory Floor Area	Total Ceiling Height (Averaged)	Total Heat Loss Perimeter (HLP)	Conservatory Y/N	Conservatory HLP	Passageway Y/N (Exposed first floor)
CONTROL	D	57	83.55	11.92	2.30	39.09	Y	2.87	Passageway (5.55m2)
DEA 1	F	26	86.42	10.35	2.20	40.58	Y	3.36	No
DEA 2	D	55	94.26	N/A	2.42	38.77	N	N/A	Passageway (5.58m2)
DEA 3	E	53	81.11	11.50	2.24	40.27	Y	3.05	No
DEA 4	E	54	82.57	10.92	2.28	41.60	Y	2.95	Passageway (5.53m2)
DEA 5	D	61	85.79	11.05	2.15	35.04	Y	3.12	No
DEA 6	E	48	85.81	10.35	2.11	41.32	Y	3.36	No
DEA 7	E	53	66.01	11.00	2.50	28.50	Y	2.90	Passagway (5.52)
DEA 8	D	57	83.25	11.59	2.29	39.67	Y	3.10	No
DEA 9	D	57	82.33	10.97	2.16	33.83	Y	3.12	No
DEA 10	D	58	82.77	11.27	2.44	38.30	Y	2.85	Passageway (5.59)
Test EPCs Mean	E	46.5	81.78	11.00	2.28	37.68		3.09	
Test EPCs Standard Deviation	10.95		5.84	1.24	0.13	4.14		0.17	

As with the SAP scores of this second test EPC, there is much improved overall consistency of all inputs when compared with that seen in the first test EPC. Standard deviation for the dwelling floor area is less than half that for test EPC 1, down from 5.84 to 2.44, and the conservatory floor area is also more consistent, down in test EPC 2 to 0.89, from EPC 1's standard deviation of 1.24. Similarly, exposed heat loss perimeter, an important calculation which, as noted above, can have a notable impact on SAP scores, is nearly halved, from 4.14 in test EPC 1, to 2.12 here. These are all important geometric calculations which have a significant combined impact on overall scores. Their consistency here contributes to the overall scores.

There appears to have been some confusion over the heat loss perimeter of the conservatory, brought about largely by DEA 9's calculations, which seem to have left off one elevation – possibly lead by an assumption that this elevation was attached. Standard deviation here is a little higher, up from 0.17 to 0.71. And ceiling heights also yielded a slightly higher standard deviation in test EPC 2, up from 0.13 in test EPC 1 to 0.21 here. But these are low standard deviations in the wider context – such that an assumption that they may 'come out in the wash' if EPCs on properties of this type be produced en-masse, may be considered reasonable. This is supported by mean floor area and ceiling height – arguably the most important of all geometric calculations, being within 2% of the control, like the SAP rating itself. Means across all geometric criteria are within 10% of the control.

It may make an interesting case for further research to take entries in isolation, and apply them to the control, to see how variation in any one single dwelling attribute, or input, would affect the EPC, where all other inputs are equal. Here, for example, the total floor area is measured by DEA 6 at 169m^2, and by DEA 3 at 143m^2. It may be reasonable to assume that these variations in isolation would be likely to yield markedly different SAP scores, and the figures are worthy of note as a shortcoming of the DEA's ability to measure a floor area accurately –arguably an essential task if an accurate EPC is to be produced. However, in the interests of bounding the research, this exercise is not undertaken here.

5.7.3 Property 2 heating system

Stone refers to main heating system efficiency: this is essentially the boiler efficiency only, and not heating controls (which they score separately as having an influence some way down the list of key factors), nor secondary heating systems, which they also believe to have less of an impact. While the heating boiler is noted as having the primary impact, this section will look at all heating related inputs.

Table 26 showing RdSAP bands, SAP scores, dwelling heating appliances and controls for all ten test EPCs, as well as the control EPC, at test property 2. Study strand 2, phase 2.

	SAP BAND	SAP RATING	Heating fuel	Boiler	Boiler efficiency (%)	Heating controls	Water heating	Secondary heating
CONTROL	C	70	Mains gas	Powermax 155x	82	Programmer, thermostat, TRVs	From main system	None
DEA 1	C	70	Mains gas	Powermax 155x	82	Programmer, thermostat, TRVs	From main system	None
DEA 2	C	72	Mains gas	Powermax 155x	82	Programmer, thermostat, TRVs	From main system	None
DEA 3	C	71	Mains gas	Powermax 155x	82	Programmer, thermostat, TRVs	From main system	None
DEA 4	C	71	Mains gas	Powermax 155x	82	Programmer, thermostat, TRVs	From main system	None
DEA 5	D	68	Mains gas	Powermax 140	82.1	Programmer, thermostat, TRVs	From main system	None
DEA 6	C	71	Mains gas	Powermax 155x	82	Programmer, thermostat, TRVs	From main system	None
DEA 7	C	70	Mains gas	Powermax 155x	82	Programmer, thermostat, TRVs	From main system	None
DEA 8	C	70	Mains gas	Powermax 155x	82	Programmer, thermostat, TRVs	From main system	None
DEA 9	C	71	Mains gas	Powermax 155x	82	Programmer, thermostat, TRVs	From main system	None
DEA 10	C	69	Mains gas	Powermax 155x	82	Programmer, thermostat, TRVs	From main system	None

The heating system at the second test property may be considered very simple. It consists of a condensing combination boiler, manufactured by a well-known brand, supplied to a respectable share of the market. At the time of writing, the boiler is a current model, and both its brand and model 'qualifier' (the serial number which denotes precisely which model it is) were easily accessed, on the front panel of the boiler which was located in an airing cupboard off the top floor landing. See Images 8 and 9 in Appendix M for the boiler (and also Images 10 and 11 for the heating controls). There is no secondary heating system at test property 2, and heating controls are straightforward, consisting of a programmer on the front panel of the boiler itself, a thermostat in the entrance hallway, and thermostatic radiator valves (TRVs) on most radiators, throughout the building.

To an even greater extent than dwelling geometry in the last section, the boiler and heating system attributes were keyed in by all 10 DEAs with a very high level of accuracy. All ten DEAs correctly identified the heating fuel, the existence of a programmer, a room thermostat and TRVs, and all ten correctly recorded the lack of any secondary system. Nine of the ten DEAs also recorded the boiler itself correctly, with a single error in this section being from DEA 5, who recorded the boiler inaccurately. Ironically, the boiler DEA 5 entered is fractionally more efficient than the boiler actually installed, yet theirs yielded the lowest SAP score of all the EPCs. Clearly this was attributed to factors other than heating. Overall, the recording of both the heating boiler and system controls at test property 2 may be seen as a highly accurate exercise, with little to discuss in terms of variation.

5.7.4 Property 2 external wall U-value

The third attribute of Stone is that of external walls. A 'U-value', or thermal efficient value of dwelling walls is denoted in RdSAP primarily by recording the dwelling age, and the wall construction type. Other factors, such as wall thickness also have a bearing, though to only a limited extent when compared with age and type.

Estimating the age of a dwelling can be a challenging process, but test property 2 is comparatively recently constructed, and simply by virtue of a brief appraisal of external and internal components, it may be clear to establish that none date back more than around 20 years. In addition, at this property there were clear indications that the property was constructed circa the year 2000, including printed dates within some glazing panels, and the boiler service log, attached to the boiler itself, marking its date of installation. Architectural features would under most circumstances be seen as the best possible indication as to the dwelling age, though here, while features of an earlier period have been adopted (such as redundant chimney stacks, slate covered roofs and vertical brick 'soldier' lintels over door and window reveals), possibly as a planning condition to help integrate the modern development into the wider area which consists mostly circa 1900 constructed terraced houses, none of the DEAs 'fell' for these faux features. All ten DEAs estimated the dwelling age with the correct band of 1996-2002, as can be seen from Table 27 below.

Table 27 showing RdSAP bands, SAP scores, and dwelling external wall characteristics, including year of construction, wall type, and wall thickness, at test property 2. Study strand 2, phase 2.

	SAP BAND	SAP RATING	Construction (main)	Main wall (type)	Main wall thickness (mm)
CONTROL	C	70	1996 - 2002	Timber frame	310
DEA 1	C	70	1996 - 2002	Timber frame	270
DEA 2	C	72	1996 - 2002	Timber frame	310
DEA 3	C	71	1996 - 2002	Cavity	300
DEA 4	C	71	1996 - 2002	Cavity	320
DEA 5	D	68	1996 - 2002	Timber frame	320
DEA 6	C	71	1996 - 2002	Cavity	290
DEA 7	C	70	1996 - 2002	Timber frame	280
DEA 8	C	70	1996 - 2002	Timber frame	300
DEA 9	C	71	1996 - 2002	Timber frame	310
DEA 10	C	69	1996 - 2002	Cavity	300

Again then, there is high consistency – in this case 100% consistency – among the DEA's data entries for the dwelling age. Wall age and wall type may combine to form the two most important factors in appraising the wall's thermal value, or 'U-value', as noted earlier. Establishing the second of these, construction type, presented a greater challenge at test EPC 2. More recently cavity constructed houses and those constructed with timber frames, can look very similar to one another. There are few obvious giveaways, and a brief external appraisal is unlikely to yield a confident choice, even by an experienced professional. Here, there are four key indications that would lead the experienced assessor to conclude this is a timber framed building.

1. Externally, windows tend to sit within the external skin of brickwork in a timber frame, further forward than would be the case in a masonry cavity constructed wall, where they may sit somewhere closer to the centre of the wall's depth. See images 1 & 2 in Section 7.1.3 above.

2. Within the garage, a blockwork partition would normally separate the garage from the main dwelling. Here, a skimmed plasterboard lines the partition. This sounds hollow to tap: it is likely to be mounted on a frame of some description. See image 4 in Section 7.1.3.

3. The wall thickness of a timber framed dwelling might be a little narrower than that of a cavity constructed wall constructed at the same time (much earlier cavity constructed walls are usually narrower), although in this case there is actually very little difference, and this measurement in isolation would not be at all conclusive. See image 5 in Section 7.1.3.

4. By far the clearest indication that the property is constructed with a frame, is once inspection within the roof space is complete. Here, as can be seen in image 7 of Section 7.1.3, the fire break, which divides the subject property's roof space from that of next door, is lined with a membrane of some description. An experienced assessor would expect to see a blockwork wall dividing the two properties in this were cavity constructed.

While one might argue that only point 4 above is compelling, the sum of all points may be seen as a convincing, near conclusive argument that the property is constructed with a timber frame. Six of the ten DEAs saw this evidence and recorded it correctly. Four did not, and recorded a cavity constructed property instead. As an aside, the EPC recorded against the property prior to the researcher's study commencing, also had the property recorded as being cavity constructed; see below.

Energy Performance Certificate

HM Government

11, Grosvenor Park, YORK, YO30 6BX

Dwelling type:	Mid-terrace house	**Reference number:**	8293-7728-5490-4390-1976
Date of assessment:	30 August 2017	**Type of assessment:**	RdSAP, existing dwelling
Date of certificate:	31 August 2017	**Total floor area:**	126 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

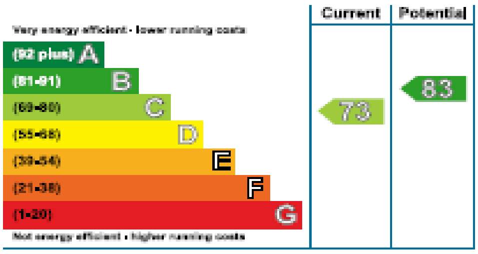
Estimated energy costs of dwelling for 3 years:	**£ 2,592**
Over 3 years you could save	**£ 183**

Estimated energy costs of this home

	Current costs	Potential costs	Potential future savings
Lighting	£ 312 over 3 years	£ 222 over 3 years	You could save £ 183 over 3 years
Heating	£ 1,926 over 3 years	£ 1,941 over 3 years	
Hot Water	£ 354 over 3 years	£ 246 over 3 years	
Totals	£ 2,592	£ 2,409	

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.

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

Recommended measures	Indicative cost	Typical savings over 3 years
1 Low energy lighting for all fixed outlets	£30	£ 75
2 Solar water heating	£4,000 - £6,000	£ 108
3 Solar photovoltaic panels, 2.5 kWp	£5,000 - £8,000	£ 813

To find out more about the recommended measures and other actions you could take today to save money, visit www.gov.uk/energy-grants-calculator or call 0300 123 1234 (standard national rate). The Green Deal may enable you to make your home warmer and cheaper to run.

Page 1 of 4

11, Grosvenor Park, YORK, YO30 6BX
31 August 2017 RRN: 8293-7728-5490-4390-1976 **Energy Performance Certificate**

Summary of this home's energy performance related features

Element	Description	Energy Efficiency
Walls	Cavity wall, as built, insulated (assumed)	★★★★☆
Roof	Pitched, 150 mm loft insulation	★★★★☆
Floor	Solid, limited insulation (assumed)	—
Windows	Fully double glazed	★★★★☆
Main heating	Boiler and radiators, mains gas	★★★★☆
Main heating controls	Programmer, room thermostat and TRVs	★★★★☆
Secondary heating	None	—
Hot water	From main system	★★★★☆
Lighting	Low energy lighting in 60% of fixed outlets	★★★★☆

Figure 32, showing the original EPC at test property 2 before the study began, which incorrectly records the property as having cavity constructed walls (see the top of page 2). Study strand 2, phase 2. Source: EPC Register, Landmark, 2017

In most cases it is unlikely that there will be documentary evidence to confirm the construction type, so in theory there will always be some ambiguity. It is this ambiguity that the experienced DEA may be able to overcome more successfully than those with less experience, or indeed anybody not paying careful attention to the available evidence. However, in this case, despite what might be seen as a fundamental building characteristic having been missed, the thermal value, or ‘U-value’ for timber frames and cavity constructed walls of the same age is actually very similar. A table of the RdSAP wall construction types and age bands is laid out in Table 28 below, along with the U-values that RdSAP attributes to walls within each category. This must be read in conjunction with Table S1, also from RdSAP and also therefore presented below, which denotes the age band of the test 2 property as ‘I’ – 1996-2002. Here, the U-value of a cavity constructed property during this period can be seen to be rated 0.45, with an equivalent timber framed dwelling constructed during the same period, at 0.40. In a context where a) the lower value denotes a higher level of thermal efficiency, but b) a cavity wall constructed in 1900 would yield a 1.5 U-value, and the same cavity wall constructed post-2012 would yield a 0.28 value, it may be reasonable to conclude that the mistake made by DEAs in this instance actually has very little impact: the RdSAP model is quite forgiving here.

Table 28. Extract from Table S6, RdSAP 2012 v9.93, showing dwelling age band, and corresponding U Value of walls. Source: RdSAP Appendix S, BRE, 2017

Table S6 : Wall U-values – England and Wales

Age band	A	B	C	D	E	F	G	H	I	J	K	L
Wall type												
Stone: granite or whinstone as built	a	a	a	a	1.7 b	1.0	0.60	0.60	0.45	0.35	0.30	0.28
Stone: sandstone or limestone as built	a	a	a	a	1.7 b	1.0	0.60	0.60	0.45	0.35	0.30	0.28
Solid brick as built	1.7	1.7	1.7	1.7	1.7	1.0	0.60	0.60	0.45	0.35	0.30	0.28
Stone/solid brick with 50 mm external or internal insulation	0.55	0.55	0.55	0.55	0.55	0.45*	0.35*	0.35*	0.30*	0.25*	0.21*	0.21*
Stone/solid brick with 100 mm external or internal insulation	0.32	0.32	0.32	0.32	0.32	0.28*	0.24*	0.24*	0.21*	0.19*	0.17*	0.16*
Stone/solid brick with 150 mm external or internal insulation	0.23	0.23	0.23	0.23	0.23	0.21*	0.18*	0.18*	0.17*	0.15*	0.14*	0.14*
Stone/solid brick with 200 mm external or internal insulation	0.18	0.18	0.18	0.18	0.18	0.17*	0.15*	0.15*	0.14*	0.13*	0.12*	0.12*
Cob (as built)	0.80	0.80	0.80	0.80	0.80	0.80	0.60	0.60	0.45	0.35	0.30	0.28
Cob with 50 mm external or internal insulation	0.40	0.40	0.40	0.40	0.40	0.40	0.35*	0.35*	0.30*	0.25*	0.21*	0.21*
Cob with 100 mm external or internal insulation	0.26	0.26	0.26	0.26	0.26	0.26	0.24*	0.24*	0.21*	0.19*	0.17*	0.16*
Cob with 150 mm external or internal insulation	0.20	0.20	0.20	0.20	0.20	0.20	0.18*	0.18*	0.17*	0.15*	0.14*	0.14*
Cob with 200 mm external or internal insulation	0.16	0.16	0.16	0.16	0.16	0.16	0.15*	0.15*	0.14*	0.13*	0.12*	0.12*
Cavity as built	1.5	1.5	1.5	1.5	1.5	1.0	0.60	0.60	0.45	0.35	0.30	0.28
Unfilled cavity with 50 mm external or internal insulation	0.53	0.53	0.53	0.53	0.53	0.45	0.35*	0.35*	0.30*	0.25*	0.21*	0.21*
Unfilled cavity with 100 mm external or internal insulation	0.32	0.32	0.32	0.32	0.32	0.30	0.24*	0.24*	0.21*	0.19*	0.17*	0.16*
Unfilled cavity with 150 mm external or internal insulation	0.23	0.23	0.23	0.23	0.23	0.21	0.18*	0.18*	0.17*	0.15*	0.14*	0.14*
Unfilled cavity with 200 mm external or internal insulation	0.18	0.18	0.18	0.18	0.18	0.17*	0.15*	0.15*	0.14*	0.13*	0.12*	0.12*
Filled cavity	0.7	0.7	0.7	0.7	0.7	0.40	0.35	0.35	0.45†	0.35†	0.30†	0.28†
Filled cavity with 50 mm external or internal insulation	0.37	0.37	0.37	0.37	0.37	0.27	0.25*	0.25*	0.25*	0.25*	0.21*	0.21*
Filled cavity with 100 mm external or internal insulation	0.25	0.25	0.25	0.25	0.25	0.20	0.19*	0.19*	0.19*	0.19*	0.17*	0.16*
Filled cavity with 150 mm external or internal insulation	0.19	0.19	0.19	0.19	0.19	0.16	0.15*	0.15*	0.15*	0.15*	0.14*	0.14*
Filled cavity with 200 mm external or internal insulation	0.16	0.16	0.16	0.16	0.16	0.13	0.13*	0.13*	0.13*	0.13*	0.12*	0.12*
Timber frame as built	2.5	1.9	1.9	1.0	0.80	0.45	0.40	0.40	0.40	0.35	0.30	0.28
Timber frame with internal insulation	0.60	0.55	0.55	0.40	0.40	0.40	0.40†	0.40†	0.40†	0.35†	0.30†	0.28†
System build as built	2.0	2.0	2.0	2.0	1.7	1.0	0.60	0.60	0.45	0.35	0.30	0.28
System build with 50 mm external or internal insulation	0.60	0.60	0.60	0.60	0.55	0.45	0.35*	0.35*	0.30*	0.25*	0.21*	0.21*
System build with 100 mm external or internal insulation	0.35	0.35	0.35	0.35	0.35	0.32*	0.24*	0.24*	0.21*	0.19*	0.17*	0.16*
System build with 150 mm external or internal insulation	0.25	0.25	0.25	0.25	0.25	0.21*	0.18*	0.18*	0.17*	0.15*	0.14*	0.14*
System build with 200 mm external or internal insulation	0.18	0.18	0.18	0.18	0.18	0.17*	0.15*	0.15*	0.14*	0.13*	0.12*	0.12*

Table 29. Table S1, RdSAP 2012 v9.93, showing dwelling age bands A-L and their corresponding year groups. For reference with Table S6 above. Source: RdSAP Appendix S, BRE, 2017

Table S1 : Age bands

	Years of construction			
Age band	**England & Wales**	**Scotland**	**Northern Ireland**	**Park home (UK)**
A	before 1900	before 1919	before 1919	-
B	1900-1929	1919-1929	1919-1929	-
C	1930-1949	1930-1949	1930-1949	-
D	1950-1966	1950-1964	1950-1973	-
E	1967-1975	1965-1975	1974-1977	-
F	1976-1982	1976-1983	1978-1985	before 1983
G	1983-1990	1984-1991	1986-1991	1983-1995
H	1991-1995	1992-1998	1992-1999	(not applicable)
I	1996-2002	1999-2002	2000-2006	1996-2005
J	2003-2006	2003-2007	(not applicable)	(not applicable)
K	2007-2011	2008-2011	2007-2013	2006 onwards
L	2012 onwards	2012 onwards	2014 onwards	(not applicable)

Prior to 1900, RdSAP does not record separate age bands, but relies instead on an accurate wall thickness and material being inputted. The procedure for calculating the value is therefore more heavily reliant on the accuracy of the DEA's measurements on site. However, wall thickness in more recently constructed buildings takes third position in terms of its overall influence, behind dwelling age and construction type. Here, all ten wall thicknesses were recorded within a range of 270 and 320mm. While it may be argued that measuring a wall thickness should be a straightforward exercise, which ought to achieve near 100% consistency, the level of variation that has arisen from these mis-measurements may not be considered significant, and does not have a large impact on wall efficiency in this instance. Also, unlike some of the results seen at test property 1, the results here 'come out in the wash': the mean overall wall thickness is 300mm: within 4% of the control.

5.8 SUMMARY OF THE SITE BASED EPC DATA

5.8.1 Introduction

The results of both control EPCs confirm the existence of variability. During both site based EPCs, each DEA went through the process in an environment which afforded them the opportunity to present the researcher with an accurate EPC, to the best of their abilities and without external influences. A further opportunity to improve accuracy was given in the researcher's approval of DEAs taking away their site notes and submitting the EPC at a later stage, all of whom accepted. Indeed, the Hawthorne effect, discussed earlier in this section, could even have led to more accurate results arising from this exercise than those submitted in the field. Despite this, EPC results for the first test property spanned three RdSAP bands: D, E and F, with SAP scores as low as 26, and as high as 61. The second EPC fared much better, spanning only two SAP bands and four SAP points. The reasons for this are discussed in this section.

5.8.1.1 EPC 1: Dwelling geometry variation

The total floor area of the control property was recorded (internally) at 66m2 at its lowest, and 86m^2 at its highest: nearly a third larger. The heat loss perimeter of the dwelling – an important measurement which denotes which walls are exposed to the open air and which adjoin neighbouring buildings – was recorded at 28.5 linear meters at its lowest, and 41.6 meters at its highest: more than a third the difference between greatest and least.

At the first EPC, DEA 2 had misunderstood the conventions relating to conservatories, and recorded the glazed kitchen extension to the rear as an extension rather than a conservatory. While common sense may dictate otherwise, the conventions are quite clear about conservatories and this may have been seen as a relatively straightforward conundrum to overcome (a conservatory has 50%+ glazed walls, and 75%+ glazed roof, according to the conventions laid out in RdSAP Appendix S (BRE, 2014)). In fact, as noted above this was after taking the site data away to input at a later date: offering them a period of reflection and research that could have led to greater accuracy. In a comparable working environment this may not have been a luxury afforded to them.

5.8.1.2 EPC 1: Dwelling heating system variation

While variation within dwelling geometry was notable, errors in collecting and inputting heating system data appear to have had more of an impact on the results. The standout result is DEA 1's assumption that the central heating boiler fuel was LPG (liquid propane gas) despite having recorded a mains gas supply to the dwelling. This may be seen as a simple error: only one in a total of 74 inputs, but in isolation this single error is likely to have brought the SAP score of the EPC submitted down, possibly by as much as two SAP bands (only modelling the EPC with the correct boiler will confirm this, which may be an interesting exercise for further research but lies beyond the boundaries of this study scope). Only three of the ten DEAs recorded all heating inputs accurately (boiler, heating controls, secondary heating). DEA 5 entered a more efficient boiler than that which existed into the model, and it may be no coincidence that their EPC produced the highest SAP rating of all: 61. DEA 6 appears to have missed the sticker on the front of the boiler with the make and model 'qualifier' on it, and so entered into RdSAP a 'generic' boiler type, as opposed to the precise make and model (this is an option within RdSAP where the boiler make, model and qualifier are not available). Worse still, the generic boiler type they selected was incorrect: the boiler at the control property was a condensing combination boiler, not a 'system boiler' (which incorporates a hot water tank). System boilers yield very different efficiencies.

5.8.1.3 EPC 1: Dwelling walls variation

In comparison with these errors and omissions, wall type - the third of three significant influences recorded by Stone (Stone et al., 2014) - may be seen as reasonably accurate. However, accuracies were still identifiable: DEA 10 estimated the construction date of the dwelling extension at around 30 years later than its actual construction date, giving it far more efficient status than it actually had, and DEA 2 classified the extension walls as solid, when walls constructed during this period were far more likely to be cavity constructed. This is an important misunderstanding that lead to far less efficient wall being recorded on the EPC which, as an aside, would lead to an automated recommendation for the wrong type of insulation to improve it.

5.8.1.4 EPC 1: environmental impact variation

On the first page of an EPC estimates are given for the costs of heating, lighting and hot water. The estimates for this are taken from the control and first ten EPCs at test property 1 are laid out in Table 30 below.

Table 30. EPC estimated carbon emissions and fuel bills per annum. First test EPC.

	Emissions t/year	Fuel bill/£
CONTROL	5.317	£1,123
DEA 1	5.466	£1,694
DEA 2	5.603	£1,187
DEA 3	5.06	£1,215
DEA 4	5.714	£1,208
DEA 5	4.292	£1,029
DEA 6	6.023	£1,373
DEA 7	4.394	£1,064
DEA 8	5.295	£1,128
DEA 9	4.589	£1,105
DEA 10	4.547	£1,086
MEDIAN	5.098	£1,209

These estimates range from as little as £1,029 to as much as £1694 per annum for annual fuel bills, and as little as 4.292 tonnes of carbon emitted per annum to as much as 6.023 tonnes per annum. The figures are interesting because they present a wide range, but do not correlate with the RdSAP scores, nor in the case of fuel bill estimates do they round down in the way other results have been found to. Also of note is that, despite the poor RdSAP rating (of 26 SAP points, compared with the next worst at 48), DEA 1's EPC emissions per year are not the highest of the group; they are the fourth highest, pitched toward the middle of the whole group, and actually the second closest (after DEA 8's) to the Control EPC's carbon emissions estimate of 5.317 tonnes per annum.

5.8.1.5 EPC 1: RdSAP defaults

In addition to the three key variables discussed above and identified as having the greatest influence by Stone, an issue of inputting 'as built' vs ' unknown' for building components where limited information is available came to light during analysis of the data. DEAs 1, 3, 6 and 9 all recorded primary roof insulation as ‘unknown’, and DEA 6 recorded the secondary, flat roof insulation as ‘unknown’ also, when ‘as built’ would have been the correct way to record each component. This is considered pertinent because the conventions relating to this are quite straightforward and misinterpreting these can have a notable impact on outcomes. The unknown option is to be used in exceptional circumstances only, either where there is conflicting information or no information at all, as it suppresses an EPC recommendation related to that element. RdSAP may also treat the element differently to ‘as built’, potentially altering the SAP score. The extract below is from Elmhurst Energy’s most recent (December 2017) RdSAP conventions document, explaining this.

3.03b ‘Unknown’ insulation type (walls, floors, roofs)
Issued March 2010, amended April 2015, August 2016, **December 2017**

This convention refers to unknown insulation type, **not** unknown insulation thickness.

Do not use the “unknown” insulation type option for insulation inappropriately as this automatically suppresses any insulation recommendation.
“Unknown” should be used only in exceptional circumstances, such as:

- When there is conflicting evidence (inspection and/or documentary) of added insulation whose presence cannot be ascertained conclusively
- For a fully boarded loft unless the householder has documentary evidence (maximum thickness is the depth of the joists) or is prepared to lift the boards
- Where there is a pitched roof and no access to the loft space or access prevented (see Convention 3.04) and no documentary evidence.

In these cases clarification must be provided in site notes.
Note: if the floor construction (not insulation level) cannot be determined, ‘unknown’ construction is appropriate.

3.03c Unknown Insulation Thickness
Issued August 2016, **December 2017**
This Convention refers to unknown insulation thickness. ‘Unknown insulation thickness’ should be used only in exceptional circumstances, such as:
- Conflicting evidence of insulation thickness (visual and/or documentary)
- When you can see insulation present but cannot measure it
- Dry lining alone does not confirm the presence of insulation

Figure 33. Extract from TB24 Elmhurst Energy All RdSAP Conventions, showing how roof insulation should be treated where limited evidence is available. Source: Elmhurst Energy, 2018

5.8.1.6 EPC 1 control error

Finally, in a discussion about this first test EPC, it should be noted that the researcher himself made an error in the initial EPC submitted to the Accrediting Body for audit prior to commencing with test EPCs from the sample of ten DEAs. This error related to the sheltered wall within the passageway, which was not recorded correctly as an 'alternative wall'. 'Alternative' here denotes a different wall type. From Photograph 3 in Appendix I, the passageway wall can be seen to be of brick rather than stone, indicating not only that it is of a different material but that it is likely to have a different wall thickness, and may lose heat at a different rate to the thicker sandstone walls to the front and rear of the main dwelling. After having made the decision to proceed with this test EPC, it was not until the researcher actually undertook the site survey and recorded the data that the level of complexity of the building was fully acknowledged. None of the ten DEAs picked up this alternative wall. Six of the DEAs did not pick up the passageway at all, and while the error that the researcher made did not affect the final SAP score, this was nonetheless an oversight which gave credence to the complexity of the test EPC property hitherto not wholly acknowledged. A decision was made at the outset to review the situation, and to consider splitting the site based phase of study into two test EPCs. The reason for this was originally to have DEAs inspect a variety of building elements from two distinct property types. However, soon after inception of this first EPC, and at the point a review was anticipated anyway, the reason for splitting this stage of the study into two EPCs is revised slightly, to add varying levels of complexity to the increased number of building components the DEAs would come across.

5.8.2 The Strand 2 EPC

The discussion above clarifies the existence of variability and makes some inroads into explaining its extent. The second EPC also confirms variability, but the extent is far less marked. These results are much more consistent, with comparatively low standard deviations across the board, and a mean across numerous key elements within the ten EPCs that match very closely with those of the control: an overall SAP score of C70 for the control, against a mean of C70.3, an overall floor area of 153m^2, against a mean of 153.1m^2, and overall ceiling heights of 2.64m, against a mean of 2.68. Heating system data was also recorded correctly by nine out of the ten DEAs, with the only error leading to a 0.2% variation in boiler efficiency. Other inputs – such as those concerning the conservatory – were not so accurate, but it may be argued that they were less important in their overall contribution to the final SAP score here (DECC, 2013; Shipworth et al., 2014).

These second EPC results would infer that variation is less marked in more modern properties, and the EPC model more effective at 'smoothing' out erroneous data than might have been expected after scrutiny of the first test EPC results. The standard deviation was calculated at the first test property at 10.95. Notwithstanding the figure being over five times the tolerable margin of error (DCLG, 2011), in isolation this might not be seen as particularly helpful, but against the backdrop of a second figure, calculated after a second study on a different property type, a context emerges. At this second test EPC, standard deviation was 1.14. This is nearly a tenth of the standard deviation at the first test property and well within the tolerable margin of error. It may indicate that variation at more straightforward properties is significantly reduced. The contrast between the two is marked. The researcher approached the study with the unsupported notion that variability existed but had no preconceived ideas as to what level of variation may occur at the outset of either study, nor how dwelling characteristics may impact upon this. Standard deviation this low, after such marked variation at test property 1, may be seen as an interesting discovery.

5.8.2.1 EPC 2: technical challenges

There were few technical conundrums at the second test property, and consequently it may be reasonable to conclude that DEAs were not tested to such a great extent. One may argue that a possible exception to this is the integral garage, which brings about the need to record a different floor type as the lowest habitable floor (the suspended floor over the garage, as opposed to the solid ground floor). This brought about varied results.

Table 31. Showing the approach taken by DEAs at test EPC 2, to record the integral garage and the space above it, in RdSAP

	SAP BAND	SAP RATING	Extension (for floor over garage) Y / N	Extension floor type	Extension roof type
CONTROL	C	70	Y	Above unheated space	Pitched, 200mm insulation
DEA 1	C	70	Y	Above unheated space	Pitched, 200mm insulation
DEA 2	C	72	Y	Above unheated space	Same dwelling above
DEA 3	C	71	Y	Above unheated space	Same dwelling above
DEA 4	C	71	Y	Solid ground floor	Same dwelling above
DEA 5	D	68	Y	Above unheated space	Same dwelling above
DEA 6	C	71	Y	Two extensions added	Two extensions added
DEA 7	C	70	Y	Two extensions added	Two extensions added
DEA 8	C	70	Y	Above unheated space	Pitched, 200mm insulation
DEA 9	C	71	Y	Above unheated space	Pitched, 200mm insulation
DEA 10	C	69	Y	Above unheated space	Pitched, 250mm insulation

In Table 31 above, DEAs can be seen to have taken a variety of different approaches to recording the integral garage, and the floor/s above it. The correct method is to separate the garage from the rest of the property, and record all floors and the roof above it, as part of an extension.

S3.11 Heat loss floor area for houses and bungalows

The area of the lowest occupied floor of the main dwelling is a ground floor. If the lowest occupied floor of any extension is not a ground floor the level of each storey in that building part is increased by 1 as described in S3.4.

For each building part examine the floor areas on each storey. If the area of any upper floor is greater than that of the floor below, the difference in these areas is an exposed or semi-exposed floor. This can occur particularly when there is an integral garage. When external dimensions are being used, however, the method of dimensional conversion can result in a small, but spurious, exposed floor area. To avoid that situation., the area of exposed floor on any level cannot be greater than the difference between the area of the current floor and the floor below measured using external dimensions. This rule is implemented as follows:

1. Calculate the exposed floor area before converting dimensions, call this A_1
2. Convert dimensions
3. Calculate exposed floor area from the internal areas, call this A_2
4. If $A_2 \leq A_1$ the exposed floor area is A_2
5. If $A_2 > A_1$ the exposed floor area is A_1
6. Repeat for all levels if dwelling has more than two storeys, and obtain the total exposed floor area.

When dimensions have been measured internally, the exposed floor area is simply the difference in area between the current floor and the floor below.

Semi-exposed floors are treated as if they were fully exposed.

The ground floor area of the main dwelling and that of any extension are treated separately as they can have different U-values.

Figure 34. Showing the method for recording a floor over an unheated space, such as an integral garage (as in this case). S3.11 Source: RdSAP Appendix S, BRE, 2017

In plan, a rectangular block the size of the garage would be separated from the otherwise larger rectangular dwelling footprint, and recorded with its own, suspended floor, and its own roof. The rest of the building is treated as the main dwelling, and all floors above the garage as the dwelling extension. From the table above, it can be seen that only four of the ten DEAs recorded this correctly: DEAs 1, 8, 9 and 10 (DEA 10 incorrectly recorded the insulation level in the loft at 250mm, but they understood the principle of separating the garage off as an extension correctly). DEAs 2, 3, 4, 5, 6, and 7 all incorrectly recorded this garage space. DEAs 2, 3, and 5 recorded only the one floor above the garage, and then reverted the rest of the building back to the main dwelling. DEAs 6 and 7 recorded two extensions, so that one could form the floor over the garage, and one a separate roof space. Both approaches are incorrect, and these misinterpretations come despite all DEAs requesting they take the data away and record and submit it at a later date for the researcher, potentially offering them a period of reflection and an opportunity for research that could have led to greater accuracy. This period of reflection might have contributed to a Hawthorne effect, discussed earlier and marked as a potential limitation, that in a 'real world' scenario may not have been available. Despite the technical mistakes here, the RdSAP model, unlike some of the errors made in test EPC 1, appears to have been forgiving: there is no marked difference in outcomes from any of these approaches. This may be considered fortunate though, and other similar errors could have led to much greater variation, as was seen in test EPC 1. This, and the proportion of DEAs (four of the ten) who assumed incorrectly that the building was constructed with masonry cavity walls, may be seen as the two most significant areas of error at test EPC 2.

5.8.2.2 EPC 2: environmental impact score

In rounding up this section, some discussion is considered appropriate for the part of the EPC given to the environmental impact of the dwelling. This is displayed on the first page of the EPC, where on overall 'EI' score is attributed to the property, and estimates are given for the cost of heating, lighting and hot water over the period of a year. These figures are laid out in Table 32 below.

Table 32. EPC estimated carbon emissions and fuel bills per annum. Study strand 2, phase 2.

	SAP BAND	SAP RATING	EI BAND	EI RATING	Emissions t/year	Fuel bill/£
CONTROL	C	70	D	64	5.25	1120
DEA 1	C	70	D	65	5.02	1092

DEA 2	C	72	D	67	4.87	1049
DEA 3	C	71	D	66	4.760	1015
DEA 4	C	71	D	65	5.508	1167
DEA 5	D	68	D	61	5.482	1151
DEA 6	C	71	D	65	5.529	1155
DEA 7	C	70	D	65	5.042	1082
DEA 8	C	70	D	64	5.168	1100
DEA 9	C	71	D	66	4.888	1047
DEA 10	C	69	D	63	5.401	1142
Test EPCs Mean	C	70.3	D	64.7	5.167	1100

These estimates range from £1,015 to £1,167 per annum for annual fuel bills, and 4.76 tonnes of carbon emitted per annum to 5.529 tonnes per annum. The figures show variation of 16% from highest to lowest carbon emission estimates, and a little less than this in variation of fuel bill estimates. The means, as with other key aspects of the EPC, are very close to the control, as can be seen. These results may be seen overall as quite consistent, and in line with the results seen elsewhere here, in relation to geometry, heating and wall U-values.

5.8.2.3 EPC 2 control

Finally in this chapter, it should be noted that the researcher's audited EPC, while having been returned as passed from the Accrediting Body, was allocated a short section of advice from the auditor, as is commonly the case when EPCs pass audit, but contain minor issues that are considered worthy of note by the auditor. Here though, this advice is incorrect, and could potentially have led to incorrectly recorded EPCs being lodged by the recipient DEA in future. From Photograph 4 of EPC 2 in Appendix I, the profile of the internal walls bounding the integral garage can be seen clearly. This profile must be recorded as an external, exposed wall, because it marks an exposed perimeter between the dwelling and an (essentially) external, unheated space. The auditor appears to have misunderstood this and recommends the garage space should not be included in the heat loss perimeter. See highlighted convention below explaining the correct procedure, the auditor's email, and the submitted site notes, calculating the heat loss perimeter of the ground floor, including the garage perimeter as 13.52m – a figure the auditor asserts is incorrect.

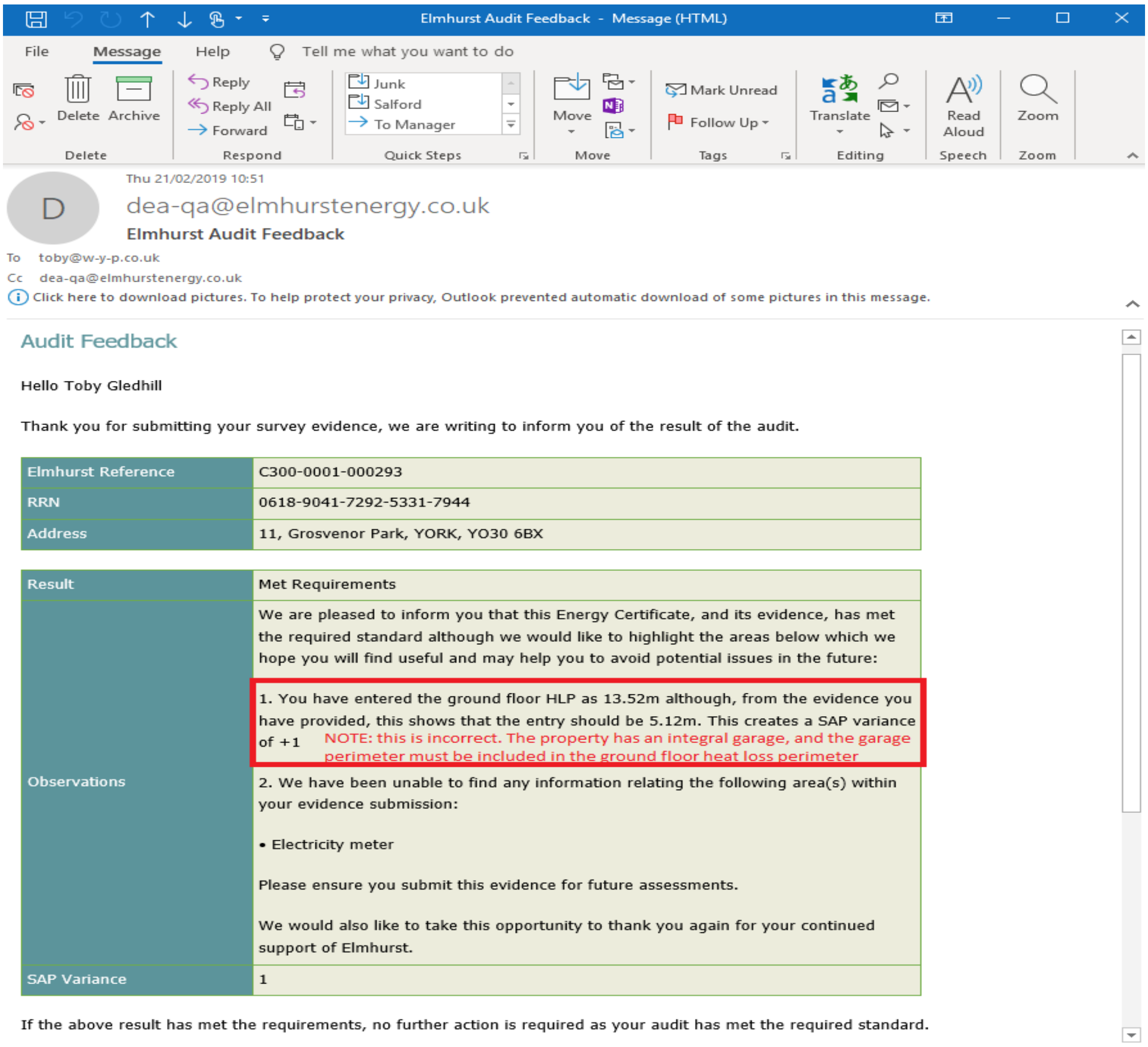
RdSAP 2012 version 9.93 (19 November 2017)

The measurements required are the floor area, exposed perimeter, party wall length and room height on each storey. Exposed perimeter includes the wall between the dwelling and an unheated garage or a separated conservatory and, in the case of a flat or maisonette, the wall between the dwelling and an unheated corridor.

Internal dimensions are permissible in all cases. In the case of a house or bungalow external dimensions for area and perimeter are usually more convenient, except where access to all sides of the building is not possible or where there are differing wall thicknesses or other aspects that would make the dimensional conversion unreliable. When using external measurements for a dwelling joined onto another dwelling (semi-detached and terraced houses) the measurement is to the mid-point of the party wall. Flats and maisonettes are usually measured internally (although it is not a requirement of the specification that internal measurements are always used and if measured externally the measurement is to the mid-point of the party wall). Whichever is chosen the same basis must be used for all parts of the dwelling. Party wall length uses the same basis as exposed perimeter.

Room heights are always measured internally within the room.

Figure 35. Extract from RdSAP Appendix S, 2012 v9.93, explaining what is included when calculating the exposed perimeter, or 'heat loss perimeter'. Source: RdSAP Appendix S, BRE, 2017



Elmhurst Audit Feedback - Message (HTML)

Thu 21/02/2019 10:51

dea-qa@elmhurstenergy.co.uk

Elmhurst Audit Feedback

To toby@w-y-p.co.uk

Cc dea-qa@elmhurstenergy.co.uk

Click here to download pictures. To help protect your privacy, Outlook prevented automatic download of some pictures in this message.

Audit Feedback

Hello Toby Gledhill

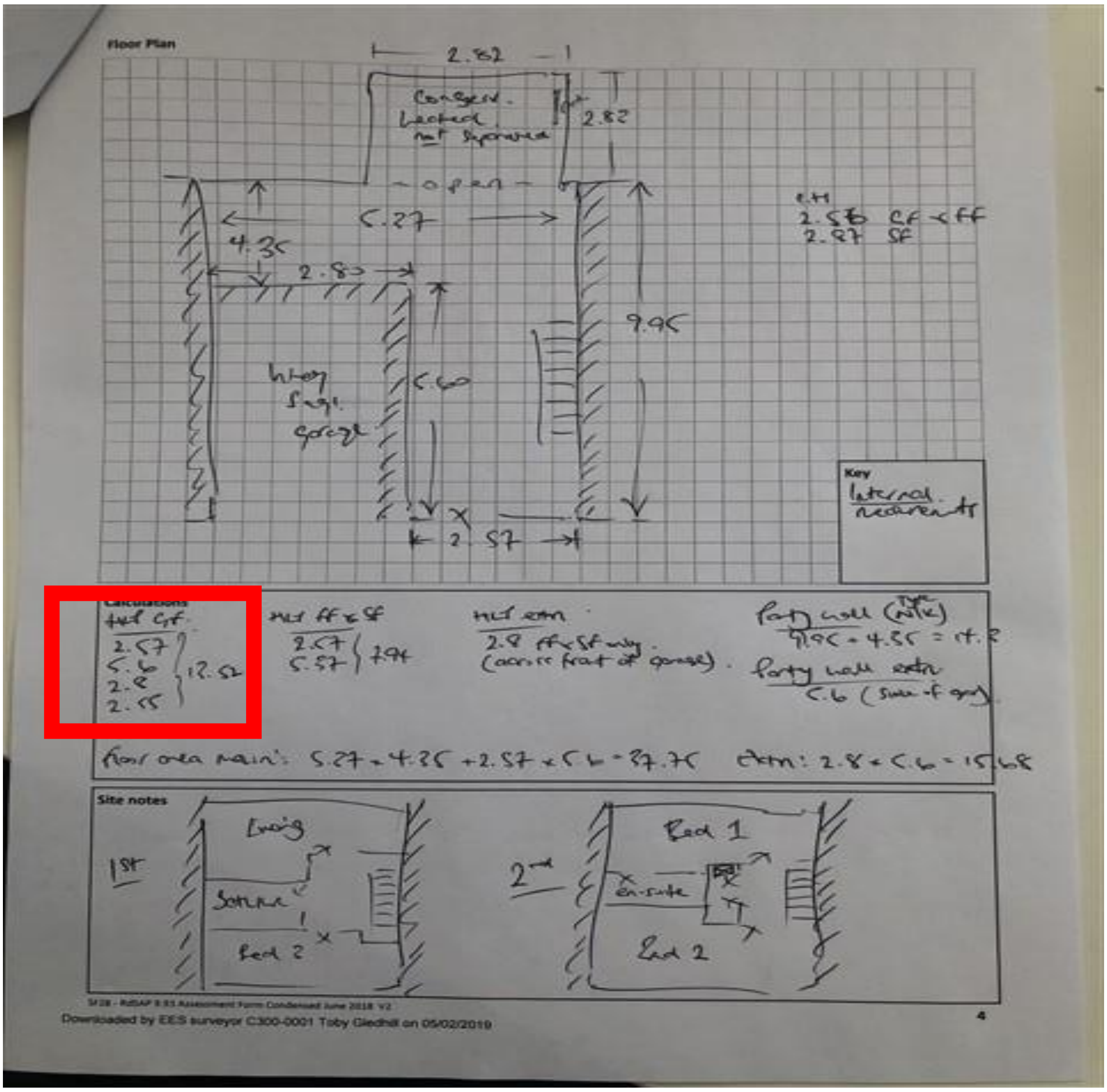
Thank you for submitting your survey evidence, we are writing to inform you of the result of the audit.

Elmhurst Reference	C300-0001-000293
RRN	0618-9041-7292-5331-7944
Address	11, Grosvenor Park, YORK, YO30 6BX

Result	Met Requirements
Observations	We are pleased to inform you that this Energy Certificate, and its evidence, has met the required standard although we would like to highlight the areas below which we hope you will find useful and may help you to avoid potential issues in the future: 1. You have entered the ground floor HLP as 13.52m although, from the evidence you have provided, this shows that the entry should be 5.12m. This creates a SAP variance of +1 NOTE: this is incorrect. The property has an integral garage, and the garage perimeter must be included in the ground floor heat loss perimeter 2. We have been unable to find any information relating the following area(s) within your evidence submission: • Electricity meter Please ensure you submit this evidence for future assessments. We would also like to take this opportunity to thank you again for your continued support of Elmhurst.
SAP Variance	1

If the above result has met the requirements, no further action is required as your audit has met the required standard.

Above and below: figures 36 & 37 showing the feedback given from the Accrediting Body on the audit for control EPC 2, and the submitted floor plans, correctly recording the garage perimeter as part of the ground floor heat loss perimeter.



5.9 SUMMARY AND INTRODUCTION TO CHAPTER 6

This chapter has recorded and discussed the findings of key data following the twenty EPCs carried out at test properties 1 and 2, during the second case study exercise. The discussion has culminated in a short discussion in Section 5.8 which begins to combine and contrast the results of EPCs 1 and 2, and draws some early inferences from the data. The next chapter will bring all of the research together, synthesising this case study data with the literature and the data from the DEA interviews. In doing so, key themes are identified and discussed, and some interpretation of these themes along with their implications are touched upon in readiness for the conclusions.

CHAPTER 6: DISCUSSION

6.1 INTRODUCTION

This chapter forms a bridge between the two case studies and the conclusions. Data from both the interview strand, and the site based EPCs are combined and discussed in this section, and the literature is brought back into the conversation both where it supports, and where it contradicts findings. The aim in bringing these strands of research back together here is to address the point of the study as directly as possible: in particular, what did the study actually uncover; what is its contribution, and what are the implications of the findings? The chapter will unfold by identifying and discussing six key areas where the research uncovered new material that has important implications for EPC variation. These areas may be summarised as:

1. The quality and perception of EPCs,
2. The auditing process for EPCs,
3. Conflicts of interest,
4. The automated bias within RdSAP,
5. Total quality management (TQM) and the EPC process, and
6. DEA training and experience.

Within each of the six sections which follow, the research findings are highlighted and briefly supported with evidence which can be found in greater detail earlier in the body of this thesis, and then in a separate section, the implications for these findings are discussed. The conclusions may be seen as a more appropriate forum to elaborate on the implications of the study findings, and so these are kept brief in this chapter.

6.1.1 Overview

While at an early stage in the literature, there was very little to be found on the subject of EPC variability, but during the course of the research, journal papers have been published on the subject, as noted at the introduction to Section 6.2 below. Throughout the interviews, DEAs made repeated assertions about the existence of variability, and both control EPCs confirmed existence of the same, albeit to markedly different extents.

Interviewees volunteered their opinions about how this variation may come about, and while not all of these assertions could be tested during the site-based exercise, triangulation of the site-based study, the interviews and the literature brought about interesting results in key areas. These may be broadly divided into three categories: those where conclusions can be drawn based on the evidence collected in the research, those results from which inferences may be drawn but where further research may be warranted before robust conclusions can be drawn, and results that may superficially appear concerning, but where further research may not necessarily be warranted. These findings are highlighted and discussed below.

6.2 EPC QUALITY AND PERCEPTION

The question of quality in various forms has arisen throughout this research (Killip, 2013; Jenkins et al., 2017; Hardy and Glew, 2019; Ahern and Norton, 2020; Tronchin and Fabbri, 2012; Gonzales-Caceres and Vic, 2019; Zero Carbon Hub, 2013; Watts et al., 2011; Gledhill et al., 2016). The interview material is saturated with support of this theme, and the variation seen in the site based EPCs also supports a lack of quality (albeit with nuances which are discussed later in this chapter). Following on from this lack of quality is a clear impact on how EPCs may be perceived.

This issue might be considered twofold. Firstly with respect to quality, consumer trust and confidence in EPCs is seen to be low. Watts (Watts et al., 2011) focused upon this aspect specifically, and while the research did not gauge public opinion about EPCs, the interviewed DEAs' perception of the EPC was that it was a poor quality product, which did not contain precise information. Numerous extracts from DEAs in Chapter 4 support this. EPC reports are lacking in detail specific to the individual property, and Watts points to potentially increased take up of measures and trust in EPC reports if they were more carefully tailored to the property to which they pertain. The interviewed DEAs make the same observation in Chapter 4.

Secondly, the quality of EPCs themselves are asserted to be unfit for their ever-growing purpose. This might be in part because they are put to uses now for which they were not originally intended. Lomas (2019) criticised the EPC's environmental impact ratings, and the estimates given in RdSAP for space and water heating, which he showed to be inaccurate in a series of modelled scenarios. He mooted the use of a ‘dwelling operational rating’ or ‘DOR’, which would measure in-use energy demand via smart meters and may yield more accurate estimates for space and water heating as a result. Smart metering is a rapidly developing technology and has the potential to provide useful domestic energy data for a variety of purposes, GDPR permitting. As the technology continues to evolve, this could see the value of EPCs in some respects diminish, in place of more advanced alternatives. To this end, this research must be seen as a moving feast, where developments must be monitored and EPCs periodically appraised for their effectiveness.

6.2.1 Implications and recommendations

This research has built on the discussion regarding the generic nature of some components within the EPC, which is not conducive to a good public perception of the EPC. The research has identified that some components of the report may be improved with relative ease. For example, rather than providing the same generic figures on all EPCs, cost estimates for insulation and heating measures could be integrated into software models, based on measurements and dwelling attributes taken from site, along with some brief ‘bullet’ identification of the specific measures recommended, and some indication as to how to go about commissioning them. In theory, this information might not be so difficult to provide, as much of it is already collected. For example, the wall surface square meterage for specification of external, internal, or cavity wall insulation systems are already held within the data set by virtue of the dwelling geometry measurements, and dwelling volume for more accurate specification of a heating system can be drawn from the same geometry inputs. This could feed into the figures presented on the EPC, in place of the generic figures given (Kelly, Crawford-Brown and Pollitt, 2012). But based on the information obtained here, the quality of the raw data collected by the DEA would have to improve if EPCs were to be of any use in this capacity. Even with the potential influence of a Hawthorne effect, noted earlier in the research as a limitation, simple measurements of dwelling geometry including the total floor area itself varied by nearly a third across the first tranche of test EPCs, and by nearly a fifth in the much simpler second test EPC. Improved auditing may help to achieve this, and this is a recommendation touched upon in relation to a separate theme discussed in the next section of this chapter.

A more recent incarnation for EPCs as carbon calculators under the government's Energy Company Obligation is revealed by the researcher in a paper that was submitted during, and alongside this study (Gledhill et al., 2016) to be flawed, albeit on limited evidence. Ahern and Norton's more recent paper (2020) reinforces this assertion with more evidence, and the first test EPC supports this, with its mean SAP score more than ten SAP points lower than the control. While Gledhill and Ahern's papers, as well as the interview material pointed to default values and poor quality assessment practice as reasons for this, the interview material supported the existence of flaws for use of the EPC for this purpose in other ways too:

'you shouldn't be unduly influenced, but I can see why people would be pushed down a route to save as much carbon as they can. As an example, for a social landlord of mine there were quite a lot of people who had secondary heating which would bring down below the standard of their solar pv installs (the Feed in Tariff has a minimum EPC Band D requirement) *and they asked that I ignore these heaters, but I couldn't do this. DEA 9*

The implications for this may be considered significant. The EPC in this context marks the status not only of the property as its stands, but of the (hypothetically, at the point of EPC production) improved property. In doing so, it estimates the carbon saved following the improvements. In estimating the saved carbon, it doubles as the invoice between the installer and the energy company, for which the public as utility bill payers ultimately pick up the cost. Following the triangulation of literature, interviews and site based study in this research, it may clearly be seen that inaccuracies could impact the status of the improved property in the eyes of the occupant, the size of the invoice, and the statistical record as an addition to the bank of EPCs accessible to academics, professionals and policy makers. Lomas' DOR may calculate likely carbon savings after insulation measures are installed based on actual energy use by the householder, and could be a superior alternative to EPCs altogether.

6.3 EPC AUDITING

At present, while the system for auditing EPCs has been reviewed and strengthened in a move described as ‘smart auditing’ (DECC, 2016) where EPCs containing anomalous data are more frequently picked up by automation for checking, there is still no additional human input. Ahern (Ahern and Norton, 2020) not only recommend Accrediting Bodies take a lead in reprimanding ‘rogue’ DEAs, but that they audit EPCs with a greater proportion of RdSAP defaults more rigorously, and DEAs interviewed for this research made the same suggestions, some years earlier:

‘it (the RdSAP model) can allow for shortcuts to be taken so where possibly more information could have been available it may be in the DEA’s interest to not research all of that and take the extra step, to take the path of least resistance and to take a way that isn’t cheating and is within the rules but isn’t quite as accurate as it could be. How DEAs approach this is quite variable, which you don’t want that when you’re doing this really’. DEA 2

Most importantly though, there is no site-based audit function undertaken, and this is not mentioned by Ahern and Norton, or in the literature elsewhere. This is an important contribution of this research, considered by the interviewees to be a significant shortcoming of the audit process:

‘The dimensions which is something that is very difficult to challenge (during an audit by the Accrediting Body) because when it’s looked at and audited and checked its done from photographs. So, looking at it you can’t necessarily say if its shorter or longer than its being presented, and you can’t really check against that or prove against that without going on site and doing that which happens very rarely to my knowledge’. DEA 2

Dwelling geometry, heating and wall type are the three areas which impact greatest upon variability according to Stone (Stone et al., 2014) and Palmer and Cooper (DECC, 2013). If a site-based inspection at either test EPC had been carried out by an appropriately trained and experienced auditor, inaccurate dimensions in particular, which varied by nearly a third at EPC 1 and nearly a fifth at EPC 2, are likely to have been picked up.

6.3.1 Implications and recommendations

Smart auditing (DECC, 2016) is an improvement, which may have picked up some key erroneous data in the site-based EPC exercise, but it is the only improvement to an audit process that has been in place since the inception of the EPC over a decade ago, and it may be reasonable to assert that it does not keep step with the broadening uses of the EPC, discussed at length in the introduction, the literature, and by the interviewed DEAs. These broadening uses bring about greater implications for inaccuracy on a dwelling-specific level and en-masse in an academic, professional and political context. With this there is a corresponding need for improved accuracy, which this research contributes towards.

Site-based audits of EPCs are likely to lead to instant improvements in the three key areas that Palmer and Cooper (2013) and Stone (2014) identify as having greatest impact on EPC variability. For example, this reseach has established that measurement inaccuracies cannot be easily picked by an audit from behind a desk, but may be quickly and efficiently corrected on site. Many of the inaccuracies found in both site-based EPCs (both those that result in variation, and those that result in the publication of misinformation, such as the timber framed wall structure of test EPC 2, which did not result in significant variation) may be rectified with relative ease this way. In addition to improving accuracy, if all DEAs are having to conform to the same, higher standard for fear of being ‘struck off’ or facing some onerous reprimand, ‘rogue’ DEAs may gradually be stripped away and fees, which interviewees almost unanimously regarded as inadequate, may gradually rise by virtue of straightforward supply and demand.

Site based audits would of course come at a cost, and this may be a key barrier to their introduction. To mitigate against this, fewer desktop audits could be commissioned by accrediting bodies in place of one, thorough site based audit, and ‘lodgment fees’; the fees charged by accrediting bodies for managing the accreditation, software and audit functions could rise to cover this, but this would have a detrimental impact on DEA’s income which is mooted in the interviews already as being poor. Increasing lodgment fees could be counter-productive if DEAs rush through the EPC process even more quickly in cogniscence of even lower pay. However, as a package of measures to improve quality and strike off 'rogue' DEAs, fees for EPCs may improve, which could fund extra resource to accrediting bodies and to DEAs. This may be a challenging, but interesting balance to monitor.

6.4 CONFLICTS OF INTEREST

Concerns were mooted by the interviewees about conflicts of interest and how these manifest in EPC reporting. The 'willful misinterpretation/manipulation' of data was reported by individual DEAs to a point of saturation:

'Let's say I've heard that certain companies insisted on DEAs stating that loft insulation is less than it should be, so they can get funding for it. There is pressure for DEAs, especially if they're self employed, to actually lean toward what they've been told (to do) to get their money'. DEA 6

While not proven within this study remit (this is marked as a limitation earlier in this research, and in the conclusions), DEAs did assert during interviews that the way in which EPCs are commissioned may be said to bring pressure to bear in some instances to 'facilitate' a particular outcome. It is clear to see how this might be a problem, for instance in situations where a Renewable Heat Incentive (RHI) payment is calculated from the EPC's contents (the less efficient the property, the greater the payment), or where the domestic Feed in Tariff (FIT) is only available to householders whose properties score an EPC Band D or above. Assuming the DEA's assertions have substance, this is likely to continue under the 2018 Minimum Energy Efficiency Standards (MEES) legislation, where the difference between one RdSAP band (E and F at present, though subject to periodic reviews) – which was spanned within the variability of both test EPCs here – would mark the difference between a landlord being able to let a property in England or Wales, or not. As an aside, these schemes all mark additional uses for the EPC, which did not exist at its inception. Job security and remuneration are likely to be strong considerations for anybody in a working environment and producing the 'wrong' type of work for an employer could be said to place both in jeopardy.

6.4.1 Implications and recommendations

It could be argued that the DEA's assertions about these conflicts, and in particular the way EPCs are commissioned do not lend themselves well to the provision of an accurate, impartial report, and a revised system of commissioning EPCs may be considered an appropriate place to commit some time and energy, and some further research if the accuracy of EPCs is to be improved.

A different system of procurement would have been needed for the test EPC at the second phase of research in order to link this back to the interview material and provide robust evidence to support the theory, so only limited conclusions can be drawn based on the interview material alone. However, it is interesting to note that this conflict of interest does not come up in the literature. In particular, it does not arise in the study by Jenkins (Jenkins et al., 2017) where the type of EPC analysed may have incorporated a conflict of interests. The limited scope to support the interviewed DEA's assertions in the site-based exercise may be seen as a limitation here, and is marked as such later in these conclusions, but it was a necessity in order to obtain a collection of impartially produced EPCs, and measure variation without external influences (so far as is practicable). While the implications of a conflict of interest may be clear, it is not possible within this study remit to make precise recommendations about how a procurement exercise may be improved, other than to assert that the removal, or at least some limitation of the potential for a conflict of interest to arise during client instructions would be beneficial.

A possible start in this regard may be the simple introduction of a 'statement of truth' at the EPC summary, such as that used (and recently revised) in Expert Witness reporting. DEAs, like Expert Witnesses, could confirm *'I believe that the facts stated in this (witness statement) are true. I understand that proceedings for (contempt of court) may be brought against anyone who makes, or causes to be made, a false statement in a document verified by a statement of truth without an honest belief in its truth.'* (justice.gov.uk., 2021). However, this may have a limited impact on improving accuracy if the underlying conflict of interest is not addressed.

6.5 RdDAP AUTOMATED BIAS

One of the key findings from the interview material in Chapter 4 was the phenomenon of rounding down, where missing or inaccurate data was entered:

'The downside of (RdSAP) EPCs is that its assuming too much. The on-construction EPCs don't assume anything, do they, but with RdSAP it's assuming too much. I think we should investigate things more'. DEA 6

This was borne out in the results of the first test EPC, where the mean SAP score was in excess of ten SAP points lower than that of the control, and a whole SAP band below it. Until recently, notwithstanding a hypothetical study by the researcher looking at the phenomenon (Gledhill et al., 2016) this had not been picked up in the literature, but Ahern (Ahern et al., 2020) does look at the headline data of a large sample of EPCs and identifies and discusses this. RdSAP defaults may be unrealistically low because most dwellings - especially older dwellings - have been improved since they were constructed, but the RdSAP defaults try to model the original dwelling component in its originally constructed form (Ahern et al., 2020; Gledhill et al., 2016).

However, Ahern notes a lack of heterogeneity of analysed housing stock as a limitation, and while the literature, interviews and first test EPC bear this phenomenon out, in EPC 2, the mean was less than half a SAP point away, and actually fractionally higher than the control. This may indicate either a) in contrast to the results taken for the first EPC, no such issue of rounding down exists after all, or b) there was so little missing, or erroneous data in this more straightforward EPC that RdSAP's automation did not need to intervene, and so little or no rounding down took place. The researcher would assert that b) is the case and point to the xml data, the consistency of the results; their collecting closely around the control, as evidence for this. As xml data has not previously been analysed in the literature, this may be regarded as a key contribution of the research in this and other aspects of the site based EPC analysis, which broadens and adds nuance to the discussion.

6.5.1 Implications and recommendations

The implications of rounding down are significant. According to the interviewed DEAs, this is a known shortcoming of the software, and a potential source of adjusting an EPC result without 'cheating' per se. It should be noted that while this claim was made a number of times, this is a mere assertion which cannot be proven within the remit of this research. But, even without considering the assertions regarding wilful misrepresentation of data, there is strong evidence in this study for the rounding down effect itself, which would result in overstated benefits for improvements, and inaccurate reporting of the status of housing stock en-masse. Clearly this has implications for individual householders, academics, professionals and importantly, the formation of policy such as RHI, MEES and FIT, along with the accurate benchmarking of UK housing stock to measure progress and set targets.

In looking to make recommendations, the results of EPC 2 in the wider context of the research may bring about a layer of complexity, as the effect of rounding down is clearly not uniform across all housing stock. Factoring in a margin for en-masse scrutiny of EPCs to account for automated bias or rounding based on the findings of EPC 1 (and the interviews) may not be hugely challenging: both standard error and the calculated mean would point to the extent of any necessary adjustment. But, if as this research appears to suggest, the necessary adjustment is not consistent across all housing stock, and less complex properties score more accurately and with little or no rounding down, weighting results with the appropriate margin of error based on housing stock type or heterogeneity may be much more challenging. Further research would be needed to establish the extent of this phenomenon across more than just two test properties in order that a robust system could be put in place for weighting results.

Realistically, it would be easier to adjust the RdSAP model to account for this, thereby circumventing any need to adjust large-scale data with some kind of weighted margin based on age and archetype. This might initially mark an improvement 'bump' in the UK housing stock's energy efficient status which could be challenging to explain following year-on-year analysis, but a greater level of accuracy, and improved forward planning could ultimately be facilitated by this. Indeed, during the course of this study the BRE Scientific Integrity Group (BRE, 2018) have improved the RdSAP default status of a solid wall and in 2020, Ahern goes some way to filling this default gap, recommending a 'stochastically based' calculation, worked up from an average of known data about a sample of investigated properties, but further research might take the form of actually investigating such properties, and compiling data that might form a reliable alternative to the current defaults.

6.6 THE EPC PROCESS AND TQM

Despite the broadening uses of EPCs, discussed at numerous points throughout this research, notwithstanding the 'smart auditing' noted above, the system for auditing EPCs has remained much the same since their inception. This could be partly attributed to the fact that the Accrediting Bodies who are tasked with auditing EPCs have no direct interest in the EPC's contents. Their role is not discussed in the literature, and this research – and the interview material in particular – has broken new ground in this regard. Accrediting Bodies are neither consumers nor suppliers: they do not rely upon the service DEAs provide, nor are they driven by targets relating to accurate EPCs by their members. It may be interesting to note whether any improvement in the quality of EPCs came about if they were. In addition, because most DEAs are self-employed and their activities are not directly connected with those of Accrediting Bodies, it appears DEAs may fall largely outside of the types of systems and procedures that could help to combine the DEA and Accrediting Body and improve standards, such as TQM (Total Quality Management) or ISO (International Organisation for Standardisation) systems. Tsang & Antony (2001) identified supplier partnership/management as being at the bottom of the list of eleven 'TQM critical success factors' during their study of service industry standards in the UK. As such, DEAs may not fall easily into any organisational structure to which they are employed as an EPC supplier either. This 'limbo' has important implications.

6.6.1 Implications and recommendations

DEAs may often play the part of supplier in an organisation's setup. For instance, in the provision of EPCs that will ultimately calculate the carbon savings for energy efficient retrofit measures, in placing a property for sale or rent through an estate agency, or as part of a housing stock condition survey commission for a social housing landlord. Even as part of the English Housing Survey (EHS), the contributing surveyors are self-employed. It may be interesting to posit the argument that while a TQM, or ISO system may help to improve the EPC process for employed, or even self-employed service providing DEAs, the primary function of such a quality management system may not usually be seen as a technical one. These systems may instead focus upon timescales, safe working practices, delivery systems, appointment booking, customer experience etc. over the actual contents of the report, which may be seen as a technical matter, to be handed over to the Accrediting Bodies for performance management. This may be seen to leave the DEA's services somewhat in limbo, so far as quality management is concerned, and a wholistic review of the system for a) recruiting DEA's services (as mentioned earlier in a different context), b) monitoring, as well as c) auditing their work (also mentioned earlier in another context) may be seen as a valuable area for further research. Maybe a bespoke TQM or ISO type system, molded to incorporate the technical contents of the EPC as opposed to the successful functioning of the wider organisational systems within which they are produced would be a suitable one for improving standards. In improving standards and accuracy, increased trust and perception may follow and consequently earnings for providing the service may rise. This could allow Accrediting Bodies to charge more for lodgment fees which could fund site-based auditing without reducing on the DEA's income. Procurement, auditing, quality, and training are all referenced as separate findings here, but when followed up, they all combine. Similar conclusions were drawn from the Zero Carbon Hub's study into new build EPC variation; 'Closing the Gap' (Zero Carbon Hub, 2013).

6.7 DEA TRAINING AND EXPERIENCE

In the first phase of the research, all of the interviewees reported that errors relating to simple tasks were felt to exist. In phase 2 - in particular at the first test EPC - these assertions were borne out. For example, a secondary heating system was missed off from the EPC inputs by one of the DEAs, and another acknowledged the existence of a mains gas supply to the property before recording the central heating boiler as LPG (liquid propane gas) fired.

More nuanced errors relating to a potential lack of DEA understanding of the complex 'conventions' (the rules relating to data collection and input) were also relayed during the interviews, and this too was evident in the results of the test EPCs where for example, a conservatory was recorded incorrectly as an extension to the main dwelling, and walls were recorded with an RdSAP option of ‘unknown’ as opposed to ‘as built’.

The interviewees reported that some DEAs were inadequately experienced, and that a related background or previous experience prior to training to become a DEA ought to be a requirement:

‘I think there needs to be a prerequisite to becoming a DEA, or at least improve the training, the course itself. Training in five days to become a DEA with no background at all and be out there doing the same job as myself who’s been doing it for years, well it’s a little bit wrong, and they’ll be getting them wrong’. DEA 1

Evidence that may begin to underline this issue was identified at both test EPCs: for example the 1970’s constructed cavity wall extension to test EPC 1 was recorded as a solid wall by one of the DEAs, where solid walls were very rarely constructed during this period. In test EPC 2, which was constructed with a timber frame, four of the ten DEAs recorded this incorrectly as masonry cavity constructed. The RdSAP model was quite forgiving of this latter error, possibly by virtue of the comparatively high, and relatively uniform thermal standards that modern walls of all types are expected to achieve (test EPC 2 was constructed circa 2000), but this may be regarded as a fundamental misunderstanding, and similar misunderstandings in other areas may have yielded more marked variation.

The interviewees clearly intimated that the training provided is not fit for its purpose, and again reasserted the point made above, that DEAs would be better placed to begin training once they have work-related experience that pre-dates this. It was noted in the literature review that, in some European countries, only experienced practitioners with a relevant professional qualification may take the training to become DEAs (Andaloro, 2010), and without necessarily knowing this, or at least without sourcing this or any other literature that supported their view, a number of the interviewees concurred. The ‘five days’ DEA training programme (Elmhurst, 2014) was considered insufficient by a majority of DEAs for what is expected of them, and the increasing importance of what it is they produce. Some rudimentary understanding of buildings in a relevant capacity prior to training may well be considered a sensible prerequisite.

The issue the interviewees had with training and experience might contribute toward a poor public perception of EPCs, which is a clear theme from the literature (Watts et al., 2011; Kelly et al., 2012; Amecke, 2012). However, while a DEA's (perceived lack of) professional experience and academic qualifications were remarked upon almost unanimously by the interview respondents, there was no clear correlation between enhanced professional or academic status and increased EPC accuracy during the site based study of this research. Those with more years of experience, as well as those with additional relevant academic and professional qualifications made errors to a broadly similar extent as those who had little experience, or no academic qualifications. There is an exception to this though, where a category of 'misunderstandings' or 'silly errors' was shown to be filled by DEAs with fewer academic or professional qualifications. Examples here are the LPG fired central heating boiler (test property 1, DEA 1) a missing solid fuel stove (test property 1, DEA 8) or the 1970 constructed solid wall, discussed just a few paragraphs earlier. However, with only twenty EPCs at two properties to compare, it may not be reasonable to draw firm conclusions or even make assertions about correlations between academic and professional experience and overall accuracy.

6.7.1 Implications and recommendations

Resolving the 'silly errors' may have been addressed to some extent by accrediting bodies upon the introduction of the smart auditing feature discussed earlier in this chapter, which targets properties containing conflicting, or unusual data. The LPG boiler recorded by a DEA at test property 1 where a mains gas supply was available, for example, may well have been picked up by this, as might the 1970's constructed solid wall. These would be unusual features that would attract the automated, smart auditor's attention. This may be seen as an encouraging development. However, in addition to errors which may be seen as quite blatant misunderstandings such as these, the data appeared to show that other important errors such as variations in levels of loft insulation, wall thickness or overall dimensions were made in equal numbers from those with greater academic and professional experience, as with those without. While there has been discussion already about other influences that may have triggered these errors, the assertions made during the interviews that some academic and/or professional experience should be a prerequisite are not wholly supported by the case study data. This is also borne out in the literature: Imam (Imam et al., 2017) found in a comparable study of 108 building energy modelers, that *'higher level qualifications, or having many years of experience in modelling did not improve the accuracy of people's predictions'*. While not all errors will be candidates for smart auditing, and very few measurement errors will be picked up, the issue of inadequate experience brought up within the interviews is not consistently borne out in the research, and where there are errors emanating from a lack of experience, these may be covered off by smart auditing in many instances. This may therefore not be seen as a more pressing matter for further action.

6.8 SUMMARY AND INTRODUCTION TO THE NEXT SECTION

This chapter has summarised key contributions of the research, discussing them and touching upon their implications by drawing on data from the literature review, the DEA interviews and the site based EPCs. While these issues have arisen throughout the research within the boundaries of each chapter's focus, for the first time in this chapter, findings have been categorised into themes and synthesised with data from the entire thesis. This has helped to form a coherent narrative and stronger, more evidence-based arguments.

The conclusions which follow will focus less upon the data collected in the literature and case study chapters, and more upon interpretation and the implications of the findings, as well as how the research may actually help limit EPC variability in future.

CHAPTER 7: CONCLUSIONS

7.1 INTRODUCTION

This research has explored the phenomenon of variability within energy performance certificates (EPCs). The reason this is considered important is because in the UK, EPCs continue to become more widely used, for a broadening range of purposes since their inception just over a decade ago. The ramifications for variation are, correspondingly, more important than ever. There is limited research on the subject, and this thesis has identified, then filled a gap in the existing knowledge.

This research identifies issues for practice that may potentially have significant implications. There is literature pointing to variability of EPCs, but much of this focuses on the software model used for calculating energy ratings, as opposed to the energy assessors themselves. Where the energy assessment process is touched upon, there is limited data available for scrutiny. Among the most pertinent to this research, Ahern and Gledhill (Ahern and Norton, 2019; Gledhill, 2016) look at RdSAP defaults, Hardy's and Crawley's studies (Hardy and Glew, 2019; Crawley et al., 2019) looked at duplicated, lodged EPCs on the national EPC register where vast numbers of EPCs were available to view, but only headline data was available for scurinty; Tronchin's study (Tronchin & Fabbri, 2012) was carried out at a single dwelling with simple characteristics, and Jenkins (Jenkins et al., 2017), had only headline data from 29 scrutinised EPCs, and adopted a research approach that could possibly have compromised the assessor's impartiality, hence the data collected. For point of note barring Tronchin, all these papers were published since this research began. Even now, despite a number of recent publications on EPC variability, there is still no literature focusing specifically on the DEA's role within the EPC process, none which gauges their opinion in any format/forum, and no literature that scrutinises the EPC's xml data – the data sheet showing all EPC inputs, which allows for the sort of detailed analysis of EPCs that has been carried out here. These may be regarded as important shortcomings and accordingly, an important contribution has been made here.

The DEA interview material in Chapter 4 clearly points to areas where the assessor may see and record things differently, and some of the reasons for this are speculated upon by the respondents. Some of their assertions link well to the evidence in papers produced since the research began, including (though not limited to) those from Hardy (2019) and Jenkins (2017) noted above. Equally as importantly, much of the interviewed DEA's observations triangulate with data from the two test EPCs carried out as a second tranche of research here, discussed in Chapter 5. Data analysis from the interviews and the twenty EPCs undertaken at two properties clearly point to variability, which is wide ranging in some cases, though actually much less marked in other cases. This helps to build a picture around the existing literature and importantly - if action is to be taken to increase accuracy of EPCs - points to some of the key reasons behind EPC variation, along with where it may be strongest and what might be done to help to improve accuracy.

7.2 MAIN FINDINGS AND RECOMMENDATIONS

In condensed form, the key findings of the research, along with recommendations as to how these could be addressed, are categorised as follows.

7.2.1 EPC Quality and perception

The research interview material is saturated with comments relating to a lack of quality, and poor perception of the EPC, and the literature supports this. Variation seen in the site based EPCs may also be said to support limited quality and a clear impact on how EPCs may be perceived as a consequence. The reasons for this are discussed in Chapter 6. Some components of the EPC may be improved with relative ease. For example, rather than providing the same generic figures on all EPCs, cost estimates for insulation and heating measures could be integrated into software models, based on measurements and dwelling attributes taken from site, along with some brief 'bullet' identification of the specific measures recommended, and some indication as to how to go about commissioning them. In theory, this information might not be so difficult to provide, as much of it is already collected. If the figures presented on the EPC were more tailored to the building it relates to, quality and perception may well be improved. However, even with the potential influence of a Hawthorne effect, noted earlier in the research as a limitation, simple measurements of dwelling geometry including the total floor area itself varied by nearly a third across the first tranche of test EPCs, and by nearly a fifth in the much simpler second test EPC. These simple tasks must be carried out to a higher standard before any meaningful results can be presented. Improved auditing may help to achieve this, and this is a recommendation touched upon in relation to a separate theme discussed in the next section.

More recent incarnations for EPCs as carbon/heat calculators under the government's Renewable Heat Incentive and Energy Company Obligation are revealed - albeit on limited evidence in this research - to be flawed, and the implications for this may be considered significant. The EPC in this context marks the status of the improved property, and estimates the carbon saved or heat outputted following the improvements. In estimating saved carbon, the EPC doubles as an invoice between the installer and the energy company, for which the public as bill payers ultimately pick up the cost. Inaccuracies may therefore impact the status of the improved property in the eyes of the occupant, the size of the invoice, and the statistical record as an addition to the bank of EPCs accessible to academics, professionals and policy makers. Lomas (2019) discussed a system for measuring energy use and heat demand based on smart metering, which could become a superior alternative to EPCs altogether, in some circumstances.

7.2.2 EPC auditing

At present, while the system for auditing EPCs has been reviewed and strengthened in a move described as 'smart auditing' where EPCs containing anomalous data are more frequently picked up by automation for checking, but there is no site-based audit function undertaken and this is not mentioned as a shortcoming in the literature. This is considered by the interviewees to be a significant shortcoming of the audit process. Dwelling geometry, heating and wall type are the three areas which impact greatest upon variability according to Stone (Stone et al., 2014) and Palmer and Cooper (DECC, 2013). If a site-based inspection at either test EPC had been carried out by an auditor, then inaccurate dimensions in particular are likely to have been picked up. Smart auditing is an improvement which may well have picked up key erroneous data in the site-based

EPC exercise, but it is the only key improvement to an audit process that has been in place since the inception of the EPC over a decade ago, and it may be reasonable to assert that it does not keep step with the broadening uses of the EPC. These broadening uses bring about greater implications for inaccuracy on a dwelling-specific level and in an academic, professional and political context, and a corresponding need for improved accuracy.

Site based audits of EPCs are likely to lead to instant improvements in the three key areas that Palmer and Cooper (2013) and Stone (2014) identify as having greatest impact on EPC variability. Measurement inaccuracies, for example, cannot be easily picked by an audit from behind a desk, but may be quickly and efficiently corrected on site. Many of the inaccuracies found in both site-based EPCs (both those that result in variation, and those that result in the publication of misinformation, such as the timber framed wall structure of test EPC 2, which did not result in significant variation) may be rectified with relative ease this way. In addition to improving accuracy, if all DEAs are having to conform to the same, higher standard for fear of being 'struck off' or facing some onerous reprimand, 'rogue' DEAs may gradually be stripped away and fees, which interviewees almost unanimously regarded as inadequate, may gradually rise by virtue of straightforward supply and demand.

7.2.3 Conflicts of Interest

Concerns were mooted by the interviewees about conflicts of interest and how these manifest in EPC reporting. The 'willful misinterpretation/manipulation' of data was reported by individual DEAs to a point of saturation. While not proven within this study remit (this is marked as a limitation), DEAs did assert during interviews that the way in which EPCs are commissioned may be said to bring pressure to bear in some instances to 'facilitate' a particular outcome. Assuming the DEA's assertions have substance, this is likely to have impact the Renewable Heat Incentive (RHI) programme, where subsidy to the householder (and procurer of the EPC) is calculated from the EPC's contents (the less efficient the property, the greater the payment), or where the domestic Feed in Tariff (FIT) is only available to householders whose properties score an EPC Band D or above, as well as under the 2018 Minimum Energy Efficiency Standards (MEES) legislation, where the difference between one RdSAP band (E and F at present, though subject to periodic reviews) – which was spanned within the variability of both test EPCs here – would mark the difference between a landlord being able to rent out a property in England or Wales, or not. Job security and remuneration are likely to be strong considerations for anybody in a working environment and producing the 'wrong' type of work for an employer could be said to place both in jeopardy. It could be argued that the DEA's assertions about these conflicts, and in particular the way EPCs are commissioned do not lend themselves well to the provision of an impartial report, and a revised system of commissioning EPCs may be considered an appropriate place to commit some time and energy, and some further research if the accuracy of EPCs is to be improved.

A different system of procurement would have been needed for the test EPC at the second phase of research in order to link this back to the interview material and provide robust evidence to support the theory, so only limited conclusions can be drawn based on the interview material, but it is interesting to note that this conflict of interest does not come up in the literature. In particular, it does not arise in the study by Jenkins (2017) where the EPCs analysed, which were produced for Green Deal applicants, may have incorporated a conflict of interests. The limited scope to support the interviewed DEA's assertions in the site-based exercise may be seen as a limitation here and is marked as such, but it was a necessity in order to obtain a collection of impartially produced EPCs, and measure variation without external influences (so far as is practicable). While the implications of a conflict of interest may be clear, it is not possible within this study remit to make precise recommendations about how a procurement exercise may be improved, other than to assert that the removal, or at least some limitation of the potential for a conflict of interest to arise during client instructions would be beneficial. A possible start in this regard may be the simple introduction of a 'statement of truth' at the EPC summary, such as that used (and recently revised) in Expert Witness reporting. DEAs, like Expert Witnesses, could confirm *'I believe that the facts stated in this (witness statement) are true. I understand that proceedings for (contempt of court) may be brought against anyone who makes, or causes to be made, a false statement in a document verified by a statement of truth without an honest belief in its truth.'* (justice.gov.uk., 2021). However, this may have only a limited impact on accuracy if the underlying conflict of interest is not removed.

7.2.4 RdDAP automated bias

One of the key findings from the interview material in Chapter 4 was the phenomenon of rounding down by automation where data is not available. This was borne out in the results of the first test EPC, where the mean SAP score was in excess of ten SAP points lower than that of the control, and a whole SAP band below it. Until recently, notwithstanding a hypothetical study by the researcher looking at the phenomenon (Gledhill et al., 2016) this had not been picked up in the literature, but Ahern (2020) does look at the headline data of a large sample and identifies and discusses this. The implications of rounding down are significant. According to the interviewed DEAs, this is a known shortcoming of the software, and a potential source of adjusting an EPC result without 'cheating' per se. It should be noted that while it was made a number of times, this is an assertion which cannot be proven within the remit of this research. But, even without considering the assertions regarding wilful misrepresentation of data, there is strong evidence in this study for the rounding down effect itself, which would result in overstated benefits for improvements, and inaccurate reporting of the status of housing stock *en masse*. Clearly this has implications for individual householders, academics, professionals and importantly, the formation of policy such as RHI, MEES and FIT, along with the accurate benchmarking of UK housing stock to measure progress and set targets.

In looking to make recommendations, the results of the two EPCs bring about a layer of complexity, because the effect of rounding down is much more marked in the more complex EPC than it is at the simpler, second one. Factoring in a margin for *en masse* scrutiny of EPCs to account for automated bias is impractical in the circumstances, because it would not be uniform across a heterogeneous housing stock. It would be necessary then, to adjust the RdSAP model to account for this. When looking at the statistics, this might initially mark an improvement 'bump' in the UK housing stock's energy efficient status which could be challenging to explain following year-on-year analysis, but a greater level of accuracy, and improved forward planning may ultimately be facilitated by this.

7.2.5 The EPC process and Total Quality Management (TQM)

The system for auditing EPCs has remained much the same since their inception. This could be partly attributed to the fact that the Accrediting Bodies who are tasked with auditing have no direct interest in the EPC's contents. It may be interesting to note whether any improvement in the quality of EPCs came about if they had. In addition, because most DEAs are self-employed, it appears DEAs may fall largely outside of the types of systems and procedures that could help to improve standards, such as TQM (Total Quality Management) or ISO (International Organisation for Standardisation) systems. DEAs may often play the part of supplier (of services) in an organisation's setup, for instance in the provision of EPCs that will ultimately calculate the carbon savings for energy efficient retrofit measures, in placing a property for sale or rent through an estate agency, or as part of a regional or national housing stock condition survey. It may be interesting to posit the argument that while a TQM, or ISO system may help to improve the activities of employed, or even self-employed service providing DEAs, the primary function of such a quality management system may not usually be seen as a technical one. These systems may instead focus upon timescales, safe working practices, delivery systems, appointment booking, customer experience etc. over the actual contents of the report, which may be seen as a technical matter, to be handed over to the Accrediting Bodies for performance management. This may be seen to leave the DEA's services somewhat in limbo, so far as quality management is concerned, and a holistic review of the system for a) recruiting DEA's services (as mentioned earlier in a different context), b) monitoring, as well as c) auditing their work (also mentioned earlier in another context) may be seen as a valuable area for further research. Maybe a TQM or ISO-type system, specially molded to incorporate the technical contents of the EPC as opposed to the successful functioning of the wider organisational systems within which they are produced would be a suitable one for improving standards.

7.2.6 DEA training and experience

In the first phase of the research, all interviewees reported that errors relating to simple tasks were felt to exist. During the test EPCs, these assertions were borne out, and the small amount of literature that touches upon DEA input supports this too, although there is no literature investigating why DEA driven inaccuracies come about. More nuanced errors relating to a potential lack of DEA understanding of the complex 'conventions' (the rules relating to data collection and input) were also relayed during the interviews, and this too was evident in the results of the test EPCs. Evidence that may superficially underline the inexperience of DEAs was found in the 1970's constructed cavity wall extension to test EPC 1, which was recorded as a solid wall by one of the DEAs, where solid walls were very rarely constructed during this period. In test EPC 2, which was constructed with a timber frame, four of the ten DEAs recorded this incorrectly as masonry cavity constructed. The RdSAP model was quite forgiving of this latter error, possibly by virtue of the comparatively high, and relatively uniform thermal standards that modern walls of all types are expected to achieve (test EPC 2 was constructed circa 2000), but this may be regarded as a fundamental misunderstanding, and similar misunderstandings in other areas may have yielded more marked variation. Some social housing landlords or individual householders may wish to make decisions about the viability of energy efficient measures based on the cost savings they will glean, or the carbon emissions that will be saved. An EPC can be 'modelled' to show the proposed measure in situ and present the estimated carbon and cost savings on that basis. Clearly if an EPC at the same dwelling can present different dwelling characteristics, even if their overall SAP scores are broadly the same, no reliable plans regarding the viability of insulation measures or their payback can be made. Returning to the example at EPC 2, cavity constructed walls and timber frames are retrospectively insulated in very different ways, and at different costs. Clearly then, this error - despite not showing a marked variation in overall score - could have a potentially costly and damaging impact on the decision-making process of any recipient, and it may be seen as surprising that there is little literature pointing to successful negligence claims against DEAs.

It was noted in the literature review that, in some European countries, only experienced practitioners with a relevant professional qualification may take the training to become DEAs (Andaloro, 2010), and without necessarily knowing this, a number of the interviewees concurred. The 'five days' DEA training programme (Elmhurst, 2014) was considered insufficient by a majority of DEAs for what is expected of them, and the increasing importance of what it is they produce. The issue with training and experience might contribute toward a poor public perception of EPCs, which is a clear theme from the literature and interviews. However, while a DEA's (perceived lack of) professional experience and academic qualifications were remarked upon almost unanimously by the interview respondents, there was no clear correlation between enhanced professional or academic status and increased EPC accuracy during this research. Those with more years of experience, as well as those with additional relevant academic and professional qualifications made errors to a broadly similar extent as those who had little experience, or no academic qualifications. While there has been discussion already about other influences that may trigger these errors, and recommendations are made elsewhere in this section that may help to address these, the interviewees' assertions that some academic and/or professional experience should be a prerequisite are not supported by the data gathered here. This is also borne out in the literature: Imam (Imam et al., 2017) found in a comparable study of 108 building energy modelers, that *'higher level qualifications, or having many years of experience in modelling did not improve the accuracy of people's predictions'*. While improving training and CPD requirements is likely to improve overall standards, the issue of inadequate prior experience brought up within the interviews is not borne out in the research as a whole, and may not be seen as a more pressing matter for further action.

7.3 KEY CONTRIBUTIONS OF THE RESEARCH

This research set out to *'to understand the importance of the energy performance certificate (EPC) in the UK, identify the risks that may affect its accuracy, appraise the EPC process in detail, and develop potential recommendations for the future delivery and use of EPCs'*. The research has achieved this aim by adopting an appropriate methodological framework and applying academic rigour in:

- Having discussed the mechanics and political context of the EPC in detail, the research looks at the EPC's uses, the potential consequences of inaccuracies, and explains why the research is important and how it fits within the broader context to the reader,

- Identifying the risks to accuracy of EPCs by reviewing the literature, then reviewing research methods and justifying a mixed methods approach. Following this, practicing DEAs are interviewed, interview material is analysed and the results discussed, and the process of EPC delivery on site is explored,

- Carrying out a second phase of research which analyses the results of two site based EPCs, with use of the underlying xml data which has not thus far been seen in the literature. In carrying out this analysis, justification is made from the literature to focus on three key areas where inaccuracies can have the greatest effect on EPC outcomes:

that of dwelling geometry, heating systems, and wall structures, with the causes for these inaccuracies firstly analysed at face value with their varying degrees and nuances, then built upon by triangulating the findings with the literature and interview material and finally,

- Following all of the above, recommendations are made that will help improve the accuracy of EPCs, and future avenues of research are identified.

The aim and objectives have been achieved in a unique way, by using a mixed methods research model to gauge the views of practicing DEAs, and then scrutinise the product of their actions on site, to draw conclusions that have not been drawn before. This brings about the existence of new knowledge, and this contribution is important if the EPC is to remain relevant, and trust in its accuracy is to be improved. This subject is a moving feast: technology is being developed and new research is being published all the time, but despite having begun in 2014 when much of the more directly associated literature in the review here was not published, the research has adapted to these changes and is still very much relevant.

The research adds richness and robustness to the (now clearly) emerging theme of EPC variability in the existing literature but makes an original contribution by analysing EPC xml data - still at the time of writing this has not yet been used for EPC analysis - to obtain a more detailed picture and draw upon more nuanced data about variability. Furthermore, the research is entirely unique in having gauged the opinion of practicing DEA; having their thoughts and observations drive the site-based phase of research and triangulating this with the literature. In having carried out this exercise, the conclusions and recommendations may be considered robust and compelling, and may be of use not just to academics, but to policy makers and professionals.

7.4 LIMITATIONS

Limitations are discussed at various stages as the research unfolds, including within the methodology Chapter 3, and at the introductions to case study Chapters 4 and 5. However, they have not been seen together in a single section thus far. In the interests of transparency, the research limitations are summarised and briefly discussed here.

7.4.1 Sample size

The interview material collected and analysed in this section points unequivocally to EPC variability, but the sample size of 20 must be marked as comparatively small, and it is possible that different results would have been drawn from a larger, or a different sample.

However, it may be reasonable to assert at this stage that the phenomenon of EPC variability is at least partially known to exist based on the evidence collected. This is because it is unlikely that - even taking into account the limitation of interviewing only a small sample of all DEAs - with 100% acknowledgement of EPC variability within this study, there would be a very different level of acknowledgement of variability among different groups, or larger groups of DEAs elsewhere.

7.4.2 Accuracy of reporting interview material

Transcripts of the interviewee's comments were interrogated using Thematic Analysis, and quotes are placed into the relevant case study chapter verbatim, with their implications discussed. Clearly the issue of variability of EPCs is central to the focus of the interview questions posited. The issues picked up from interviewees and reported in this research are those considered most pertinent by the author. This is a judgement that follows the researcher's interpretation of the results, and should be marked as a potential limitation. In the interests of transparency it should be recorded that further data was captured from the interviews, but this was not considered relevant to the research, and so comments were not relayed or discussed.

7.4.3 Accuracy of control EPCs

It is challenging to provide an entirely robust benchmark, or control, because there is always scope for error or variation in any DEA's work. This is recorded as a limitation. This has been mitigated by submitting both control EPCs for audit by an Accrediting Body. No other research into EPC variability has taken this step. The system of auditing is discussed in Chapter 5, and in the interests of avoiding repetition, is not explained again here, but an independent audit of the researcher's work does add credence to the level of accuracy of the controls. The feedback from these audits can be seen in Appendices I and L.

7.4.4 DEA recruitment and conflicts of interest

In Chapter 3 the argument is made that the only viable procurement method for this study exercise would be to explain the study purpose to DEAs and invite them, at random, to take part in an academic study. This means there will be no direct evidence collected that may support the DEA's theories regarding the 'deliberate misrepresentation' of EPCs, which DEAs cited as being attributed to their employer's desire to achieve a specific outcome. This was an important finding during the interviews and the methodological approach breaks down a little when not all the issues identified in the first strand of research can be carried forward to the second. The strand 2 study has established variability where no external influences are brought to bear, and this ticked the greater number of boxes from the interview findings, but this must be marked as a limitation.

7.4.5 The Hawthorne effect

Related to 7.4.4 above is the Hawthorne effect. This may be summarised in brief as the undesired effect of observation during the carrying out of experimental research, and was described by Franke & Kaul (Franke RH, Kaul, JD, 1978) as 'an increase in worker productivity produced by the psychological stimulus of being singled out and made to feel important'. This is discussed in Chapter 3, and its existence is inevitable when recruiting DEAs in the full knowledge of what it is they are contribution towards. Its effect cannot be quantified within this study remit but are likely to exist and must be marked as a limitation.

7.5 OPPORTUNITIES FOR FURTHER RESEARCH

7.5.1 Further EPC modelling

Section 7.5.1 and 7.5.2 here are directly applicable to this research, where after this, more broad opportunities for further research are discussed.

Following analysis of the twenty EPCs submitted during the second phase of research, it became clear that in some instances, individual, or small numbers of errors were responsible for notable variations in EPC outcomes. For example, the liquid propane gas boiler recorded by DEA 1 at test property 1 contributed to the lowest, Band F score that any of the EPCs for that property yielded. While beyond this study scope out of necessity, it may be interesting to model the collected EPC data with inputs from the control EPC, to see precisely what impact individual errors have on an otherwise uniform EPC. This may help identify areas for DEA training and for audit focus. Similarly, it may be interesting to note how complete sections of EPC inputs such as dwelling geometry or dwelling heating would compare on EPCs where all other inputs were the same – the inputs contained within the control, for example. This may lead to a narrowing of some of the conclusions drawn here, and an aid for a focus on training, and improving outcomes. This would be a considerable undertaking of its own: a study in itself which lies beyond the scope of this research, although the data collected here could be used. Conversely however, and in the interests of balance, other seemingly fundamental errors did not yield large variations. For example, the timber framed wall structure of the second test property was incorrectly recorded as masonry cavity constructed by four of the ten DEAs, but very little variation occurred as a result. This may be due to the quite stringent thermal standards required of any wall structure constructed around twenty years ago (test property 2 was constructed circa 2000), and it would be important to target any further research carefully so as not to waste valuable time and effort on variables that are unlikely to have a great impact.

7.5.2 Follow-up DEA interviews

Following the site based EPC study, it would have been interesting to conduct a second interview with each of the participating DEAs. This could have given the researcher the opportunity to gauge the opinion of DEAs about what they had experienced: in particular about the complexity of the property, how they justified the decisions they had made, what their thoughts were about preliminary results, and whether their answers to the first interview questions would have changed after reflection, and following the site based experience. Unfortunately time and resource, along with an anticipated level of ‘participant fatigue’ prevented this second interview from taking place. A similar study with post-EPC DEA interviews ‘bolted on’ might yield interesting results, especially given this is an area where there is no existing academic literature at the time of writing.

7.5.3 EPCs and conflicts of interest

Conflicts of interest were brought up frequently by interviewed DEAs, although the study discovered no academic research on the matter, and the second phase of the study was necessarily designed in such a way as to avoid picking up variation that could have arisen due to a conflict of interests. The assertions made by interviewed DEAs may be considered concerning, and were consistent to the point of saturation, with schemes such as the MEES (Minimum Energy Efficiency Standards) the RHI (Renewable Heat Incentive) the FIT (Feed In Tariff) and the now defunct Green Deal cited as potential sources. The study by Jenkins (2017) into variation took its data from a Green Deal ‘mystery shopper’ study, but (possibly because there was no direct contact with the DEAs who carried out the EPCs) this potential conflict of interest was not acknowledged. It may be quite understandable, for example that when a prospective landlord commissions an EPC prior to renting a property that must record a Band E or above, they are likely to assert pressure on the DEA to achieve that, or when the Feed in Tariff funding is only available at its maximum rate for properties achieving a Band D or above, again, pressure on the DEA from the householder commissioning the EPC is likely to be brought to bear. In the interviews, DEA 4 talks about their experience of precisely this (Ch 4, Section 4.2.4). Further research in this area, for example by identifying a suitable test property and having EPCs carried out for a variety of different purposes on it, may yield interesting results.

7.5.4 The variability of EPC 1, and the consistency of EPC 2

The results of the ten EPCs produced at the first test property may be seen as striking in their lack of consistency, bearing out many of the assertions made by interviewed DEAs, and much of the literature. However, this is balanced by the results at the second test property, which showed remarkably consistent results. Put simply, the second test property was a modern and largely uncomplicated building, and the consistency may be attributed to its more straightforward attributes. In Hardy's study (Hardy and Glew, 2019) it was flats and maisonettes that stood out for their levels of inaccuracy, not older houses. Further investigation into the inconsistency between property types of a similar ilk to those researched here may be warranted. For example, when and at what degree of complexity do the inaccuracies creep in, and at what point does a dwelling become so complex and EPC results so varied, that one might argue it has reached a stage where the EPC is simply not fit for its purpose. Should a 'super' DEA with extra training be sourced for properties with defined levels of complexity or a certain age or type? Should 'Full SAP' (BRE, 2012) (a more complex model designed for the use of newly constructed properties, though available for any dwelling type in theory) be used instead in such circumstances? Further investigation to identify where the EPC in its current form can be trusted, and where accuracy begins to break down would help to target training, establish an age/archetype/level of complexity for which margins of error should be applied, or potentially identify a point where an alternative method for calculating the energy efficiency of buildings altogether should be sourced.

7.5.5 RdSAP rounding down

The automated replacement of data in RdSAP where information is unavailable may be seen as something akin to an automated version of Kempton's 'surveyor drift' (Kempton and Nicol, 2002). This is discussed in a hypothetical study by Gledhill (Gledhill et al., 2016) and is supported in a more recent study by Ahern (Ahern et al., 2020). The phenomenon is also backed up by interviewees and the results of the first test EPC in this research. This becomes a potentially even more serious problem when data is extrapolated to form a benchmark for dwellings at regional or national level, because the research has shown that these defaults lead to a rounding down within RdSAP, so the potential for them to 'come out in the wash' is diminished, replaced instead with a lower, less efficient median. The disparity between those properties where no defaults have been required (such as test property 2 in this research) and those where multiple defaults are used (such as test property 1) may therefore bring about a marked difference between the perceived efficiencies of dwellings that does not actually exist. Ahern (2020) makes a valuable contribution to this phenomenon but by their own admission, data from a larger, and more heterogeneous sample is needed to understand this better, and at this stage beyond recommending a review of the defaults, no specific recommendations can be made about potential actions to lessen or resolve the issue.

7.5.6 Professional and academic experience, and EPC accuracy

While the interviewees were close to being unanimous about a prerequisite for professional experience to mark eligibility for DEA training, this was not borne out in the second, site-based study. While a category of 'silly mistakes' may have been filled with a majority of the less experienced DEAs, overall, the site-based phase yielded no clear correlation between increased professional or academic experience and improved EPC accuracy. Only limited conclusions can be drawn from a study of 20 EPCs, but assuming this same pattern is repeated after scrutiny of much larger numbers (and while this in itself does bring about the potential for some value in further research into this) based on the data from this study, further research in other areas may be seen as more pressing.

7.6 SUMMARY AND FINAL STATEMENT

The social, political and economic context of energy efficiency is significant, and becoming more so. As this research process comes to a close, the government's Energy White Paper (BEIS, 2020), which draws much of its information on buildings from EPC data, reasserts the belief of the Intergovernmental Panel on Climate Change (IPCC, 2018) that 'rapid, far-reaching and unprecedented changes are needed', and that to avoid catastrophic climate change we must reduce global greenhouse gas emissions by 45% by 2030, and 100% by 2050.

Within this broad context, the DEA's function provides scope for very powerful and, if accurate, very useful data. The impact of EPC variability and how this comes about has not been scrutinised with such scope thus far. There is a marked shift from the EPC's originally intended function as a (arguably largely ignored according to Jentsch (Jentsch et al., 2011)) report that produced an arbitrary energy rating to individual consumers, to a world in which we rely increasingly upon EPC data: where EPC data is used *en masse* for the reporting of UK housing status and the shaping of future policy, where considerable amounts of money - such as that dispensed under government funded grant schemes - change hands based on their contents, and to record carbon, cost savings and the potential benefits of energy efficient improvements to the householder, and more. With this, there is a correspondingly increased need to understand EPC variability and mitigate against the risk of misreporting, and this research is a step in addressing this knowledge gap.

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APPENDICES

Appendix A: Example EPC

Energy Performance Certificate

Dwelling type:	Semi-detached house	**Reference number:**	8245-7423-3450-0708-1902
Date of assessment:	08 July 2015	**Type of assessment:**	RdSAP, existing dwelling
Date of certificate:	08 July 2015	**Total floor area:**	94 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

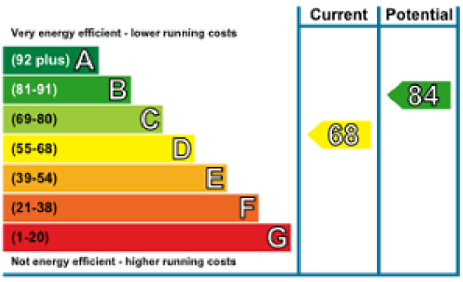
Estimated energy costs of dwelling for 3 years:	**£ 2,529**
Over 3 years you could save	**£ 558**

Estimated energy costs of this home

	Current costs	Potential costs	Potential future savings
Lighting	£ 327 over 3 years	£ 177 over 3 years	You could save £ 558 over 3 years
Heating	£ 1,875 over 3 years	£ 1,572 over 3 years	
Hot Water	£ 327 over 3 years	£ 222 over 3 years	
Totals	£ 2,529	£ 1,971	

These figures show how much the average household would spend in this property for heating, lighting and hot water. This excludes energy use for running appliances like TVs, computers and cookers, and any 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).

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

Recommended measures	Indicative cost	Typical savings over 3 years	Available with Green Deal
1 Cavity wall insulation	£500 - £1,500	£ 195	✔
2 Floor insulation (suspended floor)	£800 - £1,200	£ 129	✔
3 Low energy lighting for all fixed outlets	£90	£ 129	

See page 3 for a full list of recommendations for this property.

To find out more about the recommended measures and other actions you could take today to save money, visit **www.direct.gov.uk/savingenergy** or call **0300 123 1234** (standard national rate). The Green Deal may allow you to make your home warmer and cheaper to run at no up-front cost.

Summary of this home's energy performance related features

Element	Description	Energy Efficiency
Walls	Cavity wall, as built, no insulation (assumed)	★★☆☆☆
Roof	Pitched, 200 mm loft insulation	★★★★☆
	Roof room(s), insulated (assumed)	★★★★☆
Floor	Suspended, no insulation (assumed)	—
Windows	Fully double glazed	★★★☆☆
Main heating	Boiler and radiators, mains gas	★★★★☆
Main heating controls	Programmer, room thermostat and TRVs	★★★★☆
Secondary heating	Room heaters, mains gas	—
Hot water	From main system	★★★★☆
Lighting	Low energy lighting in 14% of fixed outlets	★★☆☆☆

Current primary energy use per square metre of floor area: 216 kWh/m² per year

The assessment does not take into consideration the physical condition of any element. 'Assumed' means that the insulation could not be inspected and an assumption has been made in the methodology based on age and type of construction.

See addendum on the last page relating to items in the table above.

Low and zero carbon energy sources

Low and zero carbon energy sources are sources of energy that release either very little or no carbon dioxide into the atmosphere when they are used. Installing these sources may help reduce energy bills as well as cutting carbon. There are none provided for this home.

Opportunity to benefit from a Green Deal on this property

The Green Deal may enable owners and occupiers to make improvements to their property to make it more energy efficient. Under a Green Deal, the cost of the improvements is repaid over time via a credit agreement. Repayments are made through a charge added to the electricity bill for the property. To see which improvements are recommended for this property, please turn to page 3. You can choose which improvements you want to install and ask for a quote from an authorised Green Deal provider. They will organise installation by an authorised Green Deal installer. If you move home, the responsibility for paying the Green Deal charge under the credit agreement passes to the new electricity bill payer.

For householders in receipt of income-related benefits, additional help may be available.

To find out more, visit **www.direct.gov.uk/savingenergy** or call **0300 123 1234**.

Energy Performance Certificate

Recommendations

The measures below will improve the energy performance of your dwelling. The performance ratings after improvements listed below are cumulative; that is, they assume the improvements have been installed in the order that they appear in the table. Further information about the recommended measures and other simple actions you could take today to save money is available at **www.direct.gov.uk/savingenergy**. Before installing measures, you should make sure you have secured the appropriate permissions, where necessary. Such permissions might include permission from your landlord (if you are a tenant) or approval under Building Regulations for certain types of work.

Measures with a green tick ✓ are likely to be fully financed through the Green Deal since the cost of the measures should be covered by the energy they save. Additional support may be available for homes where solid wall insulation is recommended. If you want to take up measures with an orange tick ✓, be aware you may need to contribute some payment up-front.

Recommended measures	Indicative cost	Typical savings per year	Rating after improvement	Green Deal finance
Cavity wall insulation	£500 - £1,500	£ 65	C70	✓ (green)
Floor insulation (suspended floor)	£800 - £1,200	£ 43	C72	✓ (orange)
Low energy lighting for all fixed outlets	£90	£ 43	C73	
Solar water heating	£4,000 - £6,000	£ 35	C75	✓ (orange)
Solar photovoltaic panels, 2.5 kWp	£5,000 - £8,000	£ 256	B84	✓ (orange)

Alternative measures

There are alternative measures below which you could also consider for your home.

- External insulation with cavity wall insulation

Choosing the right package

Visit **www.epcadviser.direct.gov.uk**, our online tool which uses information from this EPC to show you how to save money on your fuel bills. You can use this tool to personalise your Green Deal package.

Directgov
Public services all in one place

Green Deal package	Typical annual savings
Cavity wall insulation	**Total savings of £65**
Electricity/gas/other fuel savings	£0 / £65 / £0

You could finance this package of measures under the Green Deal. It could **save you £65 a year** in energy costs, based on typical energy use. Some or all of this saving would be recouped through the charge on your bill.

Energy Performance Certificate

About this document

The Energy Performance Certificate for this dwelling was produced following an energy assessment undertaken by a qualified assessor, accredited by Quidos. You can get contact details of the accreditation scheme at www.quidos.co.uk, together with details of their procedures for confirming authenticity of a certificate and for making a complaint. A copy of this EPC has been lodged on a national register. It will be publicly available and some of the underlying data may be shared with others for compliance and marketing of relevant energy efficiency information. The Government may use some of this data for research or statistical purposes. Green Deal financial details that are obtained by the Government for these purposes will not be disclosed to non-authorised recipients. The current property owner and/or tenant may opt out of having their information shared for marketing purposes.

Assessor's accreditation number:
Assessor's name:
Phone number:
E-mail address:
Related party disclosure:

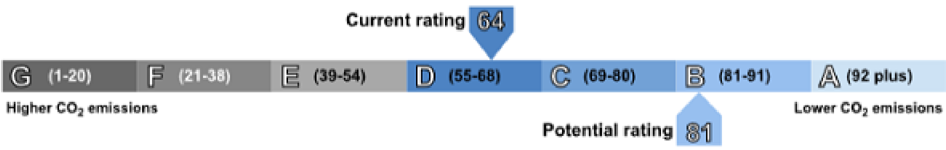
Further information about Energy Performance Certificates can be found under Frequently Asked Questions at **www.epcregister.com**.

About the impact of buildings on the environment

One of the biggest contributors to global warming is carbon dioxide. The energy we use for heating, lighting and power in homes produces over a quarter of the UK's carbon dioxide emissions.

The average household causes about 6 tonnes of carbon dioxide every year. Based on this assessment, your home currently produces approximately 3.6 tonnes of carbon dioxide every year. Adopting the recommendations in this report can reduce emissions and protect the environment. If you were to install these recommendations you could reduce this amount by 1.8 tonnes per year. You could reduce emissions even more by switching to renewable energy sources.

The environmental impact rating is a measure of a home's impact on the environment in terms of carbon dioxide (CO_2) emissions. The higher the rating the less impact it has on the environment.



Your home's heat demand

For most homes, the vast majority of energy costs derive from heating the home. Where applicable, this table shows the energy that could be saved in this property by insulating the loft and walls, based on typical energy use (shown within brackets as it is a reduction in energy use).

Heat demand	Existing dwelling	Impact of loft insulation	Impact of cavity wall insulation	Impact of solid wall insulation
Space heating (kWh per year)	10,998	N/A	(1,377)	N/A
Water heating (kWh per year)	2,210			

Appendix B: Interview Question Set

University of Salford
MANCHESTER

Toby Gledhill
University of Salford
Module 5 Domestic Energy Assessor interview questions
May 2016

1. What is your professional background?

2. How long have you held your DEA qualification for, and how many EPCs would you estimate you have produced in total?

3. What are your thoughts about the EPC *process*?

4. What do you find are biggest issues in getting a full appraisal of the property, when carrying out an EPC?

5. Do you think EPCs are variable between Assessors?

    a. (If yes) What do you feel the main causes of the variations are?
    b. (If no) What are the main reasons for the consistency?

6. What do you think are the key variables that would have an influence on the results of an EPC?

7. Do you think that the outcome of an EPC produced for sale or rental would be the same as that produced for a different purpose, for example under the government's Energy Company Obligation (ECO), or the Feed in Tariff (FiT)?

8. What improvements would ***you*** make to the EPC process?

9. Is there anything you'd like to add to this before we end the interview?

Appendix C: Ethical Applications & Approvals

University of Salford MANCHESTER

Research, Innovation and Academic Engagement Ethical Approval Panel

Doctoral & Research Support
Research and Knowledge Exchange,
Room 827, Maxwell Building
University of Salford
Manchester
M5 4WT

T +44(0)161 295 5278

www.salford.ac.uk/

18 February 2019

Toby Gledhill

Dear Toby

RE: ETHICS APPLICATION STR1819-015 – A Study into the Variability of UK Domestic Energy Assessments

Based on the information you provided, I am pleased to inform you that your application STR1819-015 has been approved.

If there are any changes to the project and/ or its methodology, please inform the Panel as soon as possible by contacting S&T-ResearchEthics@salford.ac.uk

Yours sincerely,

APHigham.

Dr Anthony Higham
Chair of the Science & Technology Research Ethics Panel

Ethical Approval Application for Interviews

University of Salford MANCHESTER SoBE Ethical Approval Panel for Taught Programmes

Application Form

for use by undergraduate and postgraduate students on Taught Programmes (Projects & Dissertations)

Who should complete this form?

This form should be completed by all students who have a high level of responsibility for how their project is carried out, including deciding the aim and who is to be involved, such as Research Projects and Dissertations.

Read and understand:

1. This form must be submitted to Blackboard as a Word document. Scanned submissions will not be considered.
2. The sections will automatically expand to the size required as you type.
3. Discuss the contents of the form with your dissertation supervisor before submitting on Blackboard.
4. If conducting interviews or questionnaires also include an example of your participant information sheet and the informed consent form/wording you will use to secure consent.

SECTION A – to be completed by ALL applicants

Last name of student:	Gledhill
First name of student:	Toby
Student ID:	@00412343
Programme of study:	Doctorate in the Built Environment (Oct 2014 start)
Supervisor:	Professor Will Swan

This project/dissertation is deemed to be:

Select one only		
	Type 1	Project work using secondary sources only – no human involvement. (Complete Section A and C only)
X	**Type 2**	Project work involving human interaction and where ethical issues can be considered and appropriately addressed.
	Type 3	Project work where there is a significant ethical dimension in connection with human interaction.

SoBE_Ethics_Form_v1, Finalised 28 October 2015

Is this application a resubmission? No (delete as appropriate)

1. Title of proposed research project

The key factors influencing variability of UK domestic energy assessments

2. Project Focus/Aim

The research aims to highlight a level of variability that has to date not been investigated to sufficient extent in the author's opinion. This research is undertaken against the backdrop of an increasing level of reliance and importance placed on the outcomes of these assessments, by government and institutions who may not fully understand the ramifications of variable assessments.

3. Project Objectives

1. Understand energy efficiency in homes, placing this within a policy context
2. Determine how homes consume energy, and how effective retrofitted energy efficiency installations reduce energy consumption
3. Examine the role of the Energy Performance Certificate (EPC) within the context of research objectives 1 and 2.
4. Examine current energy efficiency surveying practice
5. Determine potential variability in EPC outputs and discuss the reasons for these
6. Identify areas for further research.
7. Ultimately, support an improved approach for physical surveys for energy efficiency

4. Research Strategy. How will you undertake data collection for your project?

Surveyor interviews. A semi structured interview has been drafted which will be used to interview approximately twelve Domestic Energy Assessors (DEAs) with respect to their knowledge and opinion of the energy assessment process, and the purpose to which the energy assessments they produce are put within a wider context.

Please Note - Ethical approval must be obtained by all students prior to starting to collect data with people (i.e. observation / interviews / questionnaires, etc)

SECTION B (Only Necessary for Type 2 and 3 applications)

5. If you are going to work within a particular organisation do they have their own procedures for gaining ethical approval – for example, within a hospital or health centre?

I am not working within any organisation. Those DEAs interviewed will be either employed or self employed, but their employment status is not the focus of the research, rather their own professional views in respect to their work.

6. Are you going to approach individuals to be involved in your research? How will you ensure you gain informed consent from anyone involved in this study?

Yes. An overview of the study purpose will be provided within the consent form drafted, which accompanies this document, and is submitted for approval by my Supervisor.

7. How many people will be recruited or involved in the research? What is the rationale behind this number?

For this MSc dissertation, approximately twelve DEAs will be interviewed. In respect of the research aim, the number is arbitrary, but given the interview design and the time available, this may be considered a reasonable size/scope to fit the project brief. The results are hoped to provide some qualification for claims made during an earlier critical analysis, which will in turn give some foundation to the results of investigations that I propose to undertake at doctoral level.

8. Are there any other ethical issues that need to be considered?

The DEAs will be randomly approached from a pool of around 50 qualified DEAs that the researcher has had prior professional contact with. Where employed, DEAs will be asked to confirm that taking part in the researcher's work is acceptable to their employer. Any queries resulting from this will be referred back to my Supervisor for further consideration.

9. Are there any data protection issues that you need to address?

The names of the DEAs will not be revealed within the dissertation. Any names of employers or other individuals or organisations will not be revealed within the

dissertation, unless they are central to the purpose of the dissertation and have been separately discussed and approved by my Supervisor and those concerned. Should preparation of data for the UK Data Service (UKDS) be required, this can be achieved, although the sample size for this dissertation will render this very unlikely, at this stage.

10. Are there any health and safety issues that you need to address in undertaking your research? Specifically if conducting face-to-face interviews are there any lone worker safety procedures that need to be put into place?

At this stage, these will be interviews only, undertaken over the phone, at my home or at the DEA's place of work/location of his/her choosing. A risk assessment has been generated that reflects this, low risk activity, and this is submitted with this document. No work related activities will take place at this stage. This will be a consideration for the next, doctoral stage of the study process however, as energy assessments will be undertaken at this point. A separate risk assessment will be submitted for this.

SoBE Ethical Approval Panel for Taught Programmes

SECTION C – to be completed by ALL applicants

In electronically submitting this form I certify that the above information has been discussed with my dissertation supervisor and is, to the best of my knowledge, accurate and correct. I understand the need to ensure I undertake my research in a manner that reflects good principles of ethical research practice. I will notify my Supervisor of any significant changes in my methodology and re-apply for ethical approval if necessary.

Student Name: Toby Gledhill

Date submitted electronically to Blackboard: 10th May 2016

This form and any supporting documents should now be submitted via Blackboard

Ethical Approval Application for EPCs (showing resubmitted amendments highlighted in yellow).

University of Salford MANCHESTER **SoBE Ethical Approval Panel for Taught Programmes**

Application Form

for use by undergraduate and postgraduate students on Taught Programmes (Projects & Dissertations)

Who should complete this form?

This form should be completed by all students who have a high level of responsibility for how their project is carried out, including deciding the aim and who is to be involved, such as Research Projects and Dissertations.

Read and understand:

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4. If conducting interviews or questionnaires also include an example of your participant information sheet and the informed consent form/wording you will use to secure consent.

SECTION A – to be completed by ALL applicants

Last name of student:	Gledhill
First name of student:	Toby
Student ID:	@00412343
Programme of study:	Doctorate in the Built Environment (Oct 2014 start)
Supervisor:	Professor Will Swan

This project/dissertation is deemed to be:

Select one only		
	Type 1	Project work using secondary sources only – no human involvement. (Complete Section A and C only)
X	**Type 2**	Project work involving human interaction and where ethical issues can be considered and appropriately addressed.
	Type 3	Project work where there is a significant ethical dimension in connection with human interaction.

1. Title of proposed research project

A study into the variability of UK domestic energy assessments

2. Project Focus/Aim

The research aims to highlight a level of variability that has to date not been investigated sufficiently, in the author's opinion. The reason for this study is that if we are to adhere to the ambitious and binding targets of the 2008 Climate Change Act, we must measure energy efficiency accurately and consistently. This research is undertaken against this backdrop. As a result of this, there has been an increasing level of reliance and importance placed on the outcomes of energy assessments by government and institutions who may not fully understand the ramifications of variable assessments.

While there has been some considerable focus on variation between predicted energy use vs actual energy use in new buildings, (Zero Carbon Hub, 2013, 'Closing the gap between design and as-built performance, end of term report', London) there are no studies of similar depth within the boundaries of existing buildings. Among others, an evaluation by Watts, Jentsch et al (Watts, C., Jentsch, M. F. and James, P. A. (2011) 'Evaluation of domestic Energy Performance Certificates in use', Building Services Engineering Research and Technology, No. 32, Vol. 4, pp. 361–76) discussed the perceived value of the energy performance certificate back in 2011, but much has changed since then. A more recent 'mystery shopper' study by Jenkins et al. (Jenkins, D. P., Simpson, S. A. & Peacock, A., 1 Nov 2017, 'Investigating the consistency and quality of EPC ratings and assessments' Energy. 138, p. 480-489) did identify variability within energy performance certification of existing buildings, and is relevant to this study focus, but only four EPCs were produced at each property and the data inputs for each property were not available for scrutiny for the study. The study underway here looks to build on the robustness of this data. Also, the purpose for which the assessments were commissioned under Jenkins' study (the 'Green Deal' in this instance – Green Deal Orb. Available at: http://gdorb.decc.gov.uk/) may also have brought pressure to bear on the assessors, potentially leading to inaccuracies borne from a conflict of interest as opposed to 'legitimate' variation that this study aims to investigate (Gledhill, T., Kempton, J., Swan, W. and Fitton, R, The variability of UK domestic energy assessments, Journal of Building Survey, Appraisal & Valuation, Vol 4, No 4, pp. 264 - 279 , 2016).

3. Project Objectives

1. Understand energy efficiency in homes, placing this within a policy context
2. Determine how homes consume energy, and how effective retrofitted energy efficiency installations reduce energy consumption
3. Examine the role of the Energy Performance Certificate (EPC) within the context of research objectives 1 and 2.
4. Examine current energy efficiency surveying practice
5. Determine potential variability in EPC outputs and discuss the reasons for these
6. Identify areas for further research.
7. Ultimately, support an improved approach for physical surveys for energy efficiency

4. Research Strategy. How will you undertake data collection for your project?

The research methodology is based on a mixed methods approach. More specifically, the approach adopted is described by Cresswell, (Cresswell J, & Plano Clark, V, 2011, Designing and Conducting Mixed Methods Research, 2nd Edition, SAGE Publications, Ltd.) as the 'exploratory sequential design'. This involves undertaking a qualitative exploration of a topic, prior to a second quantitative phase, allowing the second phase to be informed by the first phase of research. The research phases in this research are as follows:

Phase 1 (now complete): Surveyor interviews. A semi structured interview has been undertaken encompassing 20 Domestic Energy Assessors (DEAs). Their views were sought in a nine question interview whose remit encompassed their knowledge and opinion of the energy assessment process (the interview question set is attached as Appendix A to this submission). The interview material is transcribed and has been scrutinised, primarily using thematic analysis (Braun, V, Clarke, V, 2013 'Successful Qualitative Research', Sage Publications Ltd. London).

Phase 2 (proposed from January – March 2018 – stand 1, and February – March 2019 – stand 2). Site based EPC production at two separate control properties. It is proposed that a total of 20 EPCs will be undertaken by qualified DEAs at two residential properties: ten at each. The data entries that contribute toward the production of these EPCs will be submitted for review and comparison with others, along with photos and site notes. The review of EPCs submitted will be undertaken giving special consideration to a study by Palmer & Cooper (Palmer, J. and Cooper, I. 2013 'UK energy fact file', London: Department of Energy and Climate Change) who identified particular areas within the EPC that have a greater influence upon their results.

Please Note - Ethical approval must be obtained by all students prior to starting to collect data with people (i.e. observation / interviews / questionnaires, etc)

SoBE Ethical Approval Panel for Taught Programmes

SECTION B (Only Necessary for Type 2 and 3 applications)

5. **If you are going to work within a particular organisation do they have their own procedures for gaining ethical approval – for example, within a hospital or health centre?**

I am not working within any organisation. Those DEAs producing EPCs at the control property will be either employed or self employed, but their employment status is not the focus of the research, rather their own approach and the work produced.

6. **Are you going to approach individuals to be involved in your research? How will you ensure you gain informed consent from anyone involved in this study?**

Yes. An overview of the study purposed will be provided within the consent form drafted, which accompanies this document, and is submitted for approval by my Supervisor.

7. **How many people will be recruited or involved in the research? What is the rationale behind this number?**

This work will contribute toward my final thesis and Viva. Up to twenty DEAs will take part. In respect of the research aim, the number is arbitrary, but given the mixed methods approach discussed briefly and cited in Section 2 above, along with the time available, this may be considered a reasonable size/scope to fit the project brief. The results are expected to provide some qualification for assertions made during an earlier interview stage, which will in turn give some foundation to the results of all investigations undertaken.

8. **Are there any other ethical issues that need to be considered?**

The DEAs will be randomly approached from a pool of around 50 qualified DEAs that the researcher has had prior professional contact with. 20 interviewees have already taken part in the first phase of the project, and these DEAs will be approached first. Where employed, DEAs will be asked to confirm that taking part in the researcher's work is acceptable to their employer. Any queries resulting from this will be referred back to my Supervisor for further consideration.

9. Are there any data protection issues that you need to address?

The names of the DEAs will not be revealed within the dissertation or any papers drafted for publication in journals. Any names of employers or other individuals or organisations will not be revealed within the material, unless they are central to the purpose of the dissertation and have been separately discussed and approved by my Supervisor and those concerned. Should preparation of data for the UK Data Service (UKDS) be required, this can be achieved, although the sample size for this thesis will render this unlikely.

10. Are there any health and safety issues that you need to address in undertaking your research? Specifically if conducting face-to-face interviews are there any lone worker safety procedures that need to be put into place?

Domestic energy assessments will be undertaken. This involves a non-intrusive inspection of a domestic property by a single individual (the DEA), including some working at height (internal, storey height to include head and shoulders loft inspection as a maximum). All participants will be accompanied by the researcher. A separate risk assessment is submitted for this.

SECTION C – to be completed by ALL applicants

In electronically submitting this form I certify that the above information has been discussed with my dissertation supervisor and is, to the best of my knowledge, accurate and correct. I understand the need to ensure I undertake my research in a manner that reflects good principles of ethical research practice. I will notify my Supervisor of any significant changes in my methodology and re-apply for ethical approval if necessary.

Student Name: Toby Gledhill

Date submitted electronically to Blackboard: 17-12-17 Updated 13-02-19

This form and any supporting documents should now be submitted via Blackboard

Appendix D: Participant Information Sheets

Interviews

University of Salford MANCHESTER

Science & Technology

Ethical Approval Panel for Taught Programmes
Participant Information Sheet

Study Title
A study into the factors influencing variability of UK domestic energy assessments

Invitation paragraph
I would like to invite you to take part in a research study. Before you decide you should understand why the research is being done and what it would involve for you. Please take time to read the following information carefully. Ask questions if anything you read is not clear or if you would like more information. Take time to decide whether or not to take part.

What is the purpose of the study?
The purpose of the study is to find evidence for factors that may influence variability of UK domestic energy assessments, and ultimately make recommendations as to how to improve the process and limit this variability, or mitigate against it.

Why have I been invited?
Whilst you have been chosen from a pool of appropriately qualified professional people at random, you are an appropriately qualified Domestic Energy Assessor, which is a prerequisite for our research. Also, you undertake this work on a regular basis, and have done so for some years. This makes you an ideal candidate to answer the sort of questions that the researcher wants to ask, about your profession, and your work processes.

Do I have to take part?
It is up to you to decide. We will describe the study and go through the information sheet, which we will give to you. We will then ask you to sign a consent form to show you agreed to take part. You are free to withdraw at any time, without giving a reason.

What will happen to me if I take part?
Nothing will happen to you. We would like you to be as candid as you want, and so we will not refer to any DEAs by name. DEAs will be referred to as 'DEA 1', 'DEA 2', or a similarly anonymised naming system. The information you provide will be used to further the research as outlined here, and it is hoped that this will contribute ultimately in improving the energy surveying process. As contributors to the research, you will have the first opportunity to see its results, if you wish to.

Expenses and payments?
This will be a short telephone interview, and we ask that you contribute your time free of charge on this occasion. We anticipate this will lead to further research, in the form of a 'control property EPC', which we will invite you to take part in. A fee similar to that which you would receive should you be undertaking the work commercially would be provided for this.

What will I have to do?
This is a short telephone interview. You can meet with the researcher in person for the interview if you wish to, but this is not essential. We anticipate that in the region of ten questions will be

asked about your profession. This is not a test, and we will not be asking you about your *knowledge*, but about your *opinion* on the energy assessment process and production of EPCs.

What are the possible disadvantages and risks of taking part?
Other than spending up to half an hour of your time on something that may not glean considerable reward for you, there is no other discernible disadvantage in taking part. There are no identifiable risks, as the information you provide will be anonymised for the purpose of our reporting, and your name will not be mentioned in any published material.

What are the possible benefits of taking part?
We cannot promise the study will help you but the information we get from the study will help to increase the understanding of the energy assessment process, and variability in assessments, which is aligned with your profession. You will be given early access to our findings, and this may assist you in your professional development.

What if there is a problem?
If you have a concern about any aspect of this study, you should ask to speak to the researchers who will do their best to answer your questions.

If you remain unhappy having spoken to the researcher, you should contact the researcher's supervisor (see below).

If you still remain unhappy and wish to complain formally you can do this through sending a letter setting out the details of your complaint to the researcher's Head of School, Will Swan (see below).

Professor Will Swan
School of the Built Environment

Dr Richard Fitton
School of the Built Environment

University of Salford
Salford
M5 4WT

While complaints will be taken seriously, and appropriate action taken within the University and with respect to the researcher, there is no route for compensation, insurance/indemnity claim, and therefore this would not be available to you.

Will my taking part in the study be kept confidential?
All information which is collected about you during the course of this research will be kept strictly confidential, and any information about you which leaves the university will have your name and address removed so that you cannot be recognised.

What will happen if I don't carry on with the study?
If you withdraw from the study we will destroy any identifiable samples/tape recorded interviews, but we will need to use the data collected up to your withdrawal.

What will happen to the results of the research study?
The research study information will be presented in the form of a University dissertation, and may also be published in a condensed version, as a paper in a professional or academic journal. You will not be identified in any publication/material personally. All information collected will be anonymised.

Who is organising or sponsoring the research?
The research is funded jointly by the researcher and the University of Salford. There are no other external bodies with a financial interest in this work, nor have any offered other resources such as time or materials.

Further information and contact details:

Toby Gledhill
Doctoral student at the University of Salford
7 Stoney Lane,
Chapelthorpe,
Wakefield,
WF4 3JN
toby@w-y-p.co.uk
01924 249970

Participant Information Sheet – Site Based EPCs

University of Salford MANCHESTER

Science & Technology

Ethical Approval Panel for Post Graduate Programmes
Participant Information Sheet

Study Title
A study into the variability of UK domestic energy assessments – site based exercise

Invitation paragraph
I would like to invite you to take part in a research study. Before you decide you should understand why the research is being done and what it would involve for you. Please take time to read the following information carefully. Ask questions if anything you read is not clear or if you would like more information. Take time to decide whether or not to take part.

What is the purpose of the study?
The purpose of the study is to find evidence for factors that may influence variability of UK domestic energy assessments, and ultimately make recommendations as to how to improve the process and limit this variability, or mitigate against it.

Why have I been invited?
Whilst you have been chosen from a pool of appropriately qualified professional people at random, you are an appropriately qualified Domestic Energy Assessor, which is a prerequisite for our research. Also, you undertake this work on a regular basis, and have done so for some years. This makes you an ideal candidate to take part in this site based exercise.

Do I have to take part?
It is up to you to decide. We will describe the study and go through the information sheet, which we will give to you. We will then ask you to sign a consent form to show you agreed to take part. You are free to withdraw at any time, without giving a reason.

What will happen to me if I take part?
Nothing will happen to you. We will not refer to any DEAs by name. DEAs will be referred to as 'DEA 1', 'DEA 2', or a similarly anonymised naming system. We would like you to work in the same way as you would on site, for any regular job. The information you provide will be used to further the research as outlined here, and it is hoped that this will contribute ultimately in improving the energy surveying process. As contributors to the research, you will have the first opportunity to see its results, if you wish to.

Expenses and payments?
This will be an EPC at a control property, lodged under the researcher's name, on his assessor account. The only slight difference with this EPC would be that we request you submit xml data, photos and site notes once it is complete. A fee similar to that which you would receive should you be undertaking the work commercially will be provided for this. We estimate this to be £50. The lodgement fee will be covered by us.

What will I have to do?
This is an EPC at a control property, which has been previously selected by us. You would be expected to travel out to the control property and complete the EPC in the normal way. Afterwards, we ask that site notes and photos be submitted to us. Xml data will be available to us

as the EPC will be lodged under our own account. We would like to undertake a short interview with you some weeks after the EPC is completed, also. This is not a test, and we will not be assessing your *knowledge*, but we will be looking at the way DEAs undertake the assessment process and production of EPCs. All individuals taking part will be anonymised. The EPC, xml and other site data and photographs will be kept for up to a year after the research project is finished: estimated Summer 2019, after which time it will be destroyed.

What are the possible disadvantages and risks of taking part?
There is no discernible disadvantage in taking part, nor are there any special risks, over and above those which may normally be associated with undertaking an EPC on site. There are no risks to reputation or associated organisations, as the information you provide will be anonymised for the purpose of our reporting, and your name, nor your employer's name will not be mentioned in any published material. You do of course have the right to withdraw from the study at any time.

What are the possible benefits of taking part?
Other than spending the time it takes to produce an EPC for the regular, commercial rate, there will be no notable reward for you, unless you see early access to the research produced afterwards as a reward. We cannot promise the study will help you but the information we get from the study will help to increase the understanding of the energy assessment process, and variability in assessments, which is aligned with your profession. You will be given early access to our findings, and this may assist you in your professional development.

What if there is a problem?
If you have a concern about any aspect of this study, you should ask to speak to the researchers who will do their best to answer your questions.

If you remain unhappy having spoken to the researcher, you should contact the researcher's supervisor (see below).

If you still remain unhappy and wish to complain formally you can do this through sending a letter setting out the details of your complaint to the researcher's Head of School, Will Swan (see below).

Professor Will Swan
School of the Built Environment

Dr Richard Fitton
School of the Built Environment

University of Salford
Salford
M5 4WT

While complaints will be taken seriously, and appropriate action taken within the University and with respect to the researcher, there is no route for compensation, insurance/indemnity claim, and therefore this would not be available to you.

Will my taking part in the study be kept confidential?

All information which is collected during the course of this research will be kept strictly confidential, and any information about you which leaves the university will have your name and address removed so that you cannot be recognised.

What will happen if I don't carry on with the study?
If you withdraw from the study we will destroy any identifiable samples/recorded interviews, but we will need to use the data collected up to your withdrawal.

What will happen to the results of the research study?
The research study information will be presented in the form of a University dissertation, and may also be published in a condensed version, as a paper in a professional or academic journal. You will not be identified in any publication/material personally. All information collected will be anonymised.

Who is organising or sponsoring the research?
The research is funded jointly by the researcher and the University of Salford. There are no other external bodies with a financial interest in this work, nor have any offered other resources such as time or materials.

Further information and contact details:

Toby Gledhill
Doctoral student at the University of Salford
7 Stoney Lane,
Chapelthorpe,
Wakefield,
WF4 3JN
toby@w-y-p.co.uk
01924 249970

Appendix E: Participant Consent Forms

Interviews

University of Salford MANCHESTER

Science & Technology

Ethical Approval Panel for Taught Programmes
Research Participant Consent Form

Title of Project: A study into the variability of UK domestic energy assessments

Ref No: TBC

Name of Researcher: Toby Gledhill

(Delete as appropriate)

➢ I confirm that I have read and understood the information sheet for the above study (version x- date) and what my contribution will be.	**Yes**	**No**	
➢ I have been given the opportunity to ask questions (face to face, via telephone and e-mail)	**Yes**	**No**	
➢ I agree to take part in the interview	**Yes**	**No**	**NA**
➢ I agree to the interview being tape recorded	**Yes**	**No**	**NA**
➢ I agree to digital images being taken during the research exercises	**Yes**	**No**	**NA**
➢ I understand that my participation is voluntary and that I can withdraw from the research at any time **without giving any reason**	**Yes**	**No**	
➢ **I agree to take part in the above study**	**Yes**	**No**	

Name of participant:

Signature

Date:

Name of researcher taking consent: Toby Gledhill

Researcher's e-mail address: toby@w-y-p.co.uk

If you have any concerns about this research that have not been addressed by the researcher, please contact the researcher's supervisor via the contact details below:

Supervisor's name: Professor Will Swan

Supervisor's email address: W.C.Swan@salford.ac.uk

ParticipantConsentFormSep20115 Page 1

University of Salford MANCHESTER

Science & Technology

Ethical Approval Panel for Post Graduate Research Programmes
Research Participant Consent Form

Title of Project: Site-based control property exercise: study into the variability of UK domestic energy assessments

Name of Researcher: Toby Gledhill

(Delete as appropriate)

➢ I confirm that I have read and understood the information sheet for the above study and what my anonymous contribution will be	**Yes**	**No**	
➢ I have been given the opportunity to ask questions (face to face, via telephone and e-mail)	**Yes**	**No**	
➢ I agree to take part in the case study	**Yes**	**No**	**NA**
➢ I agree to submit the xml data, site notes and photographs from the exercise which will be kept for up to one year after the study completion (study anticipated for completion Summer 2019)	**Yes**	**No**	**NA**
➢ I agree to digital images being taken during the research exercises	**Yes**	**No**	**NA**
➢ I understand that my participation is voluntary and that I can withdraw from the research at any time **without giving any reason**	**Yes**	**No**	
➢ **I agree to take part in the above study**	**Yes**	**No**	

Name of participant:

Signature

Date:

Name of researcher taking consent: Toby Gledhill

Researcher's e-mail address: toby@w-y-p.co.uk

If you have any concerns about this research that have not been addressed by the researcher, please contact the researcher's supervisor via the contact details below:

Supervisor's name: Professor Will Swan

Supervisor's email address: W.C.Swan@salford.ac.uk

ParticipantConsentFormSep20115 Page 1

Appendix F: Risk Assessments

Interviews

RISK ASSESSMENT FOR RESEARCH AND PROJECTS COVER SHEET.

Student's surname	Gledhill
Student's forenames	Toby
Section of School	School of the Built Environment
Degree	Professional Doctorate
Title of Project	Masters dissertation
Brief description of the project	Domestic Energy Assessor (DEA) interviews, for the purpose of highlighting a level of understanding about the profession and the wider context that surrounds the profession
Supervisor's name	Professor Will Swan
Reserve supervisor in case of absence.	Dr Richard Fitton
Locations where work will be carried out	TBC: home, office or mutually convenient location ie café

It is the responsibility of the PI / Supervisor to ensure the risk assessment is suitable and sufficient and that risk assessments are reviewed should any significant changes to the project / research be made.

Risk assessment (RA) tracking;

Hazard	RA required	RA complete	Risk level as identified in RA	Authorised as suitable and sufficient by supervisor
Initial Risk Assessment.	✓	✓		
Physical / mechanical / electrical / animal	x	*If any of these risks are to be encountered during the research, you must complete the full Risk Assessment Form, not this one.*		
Biological – microorganisms	x			
Chemical	x			
Radiation	x			
Travel / Fieldwork	✓	✓		

CST/Risk assessment forms/DL/02/2014

1

Host Organisation	X			

I shall be working in the establishment named below (where applicable):
Name; Toby Gledhill, W-Y-P Gledhill Address; 7 Stoney Lane, Chapelthorpe, Wakefield WF4 3JN Tel; 01924 249970

Emergency Contact Details.

Role	Name	Telephone & email
Student	Toby Gledhill	07889018581 toby@w-y-p.co.uk
Academic Supervisor	Will Swan	07876 580 189 W.C.Swan@salford.ac.uk
Host organisation Supervisor (where applicable)	N/A	N/A

Initial Risk Assessment.

Location:	Task/Activity/Environment:		Date of Assessment:
Identify Hazards which could cause harm:	Identify risks = what could go wrong if hazards cause harm:		
No.	Hazard	No.	Risk
	Physical / mechanical / electrical / animal		N/A
	Biological		N/A
	Chemical		N/A
	Radiation / Lasers		N/A
	Lone working		N/A
✓	Travel / Fieldwork		**Travel to meet in person is a possibility, but with no special circumstances. Telephone interviews are anticipated at this stage.**
	Disposal of waste material		N/A

List groups of people who could be affected:	**Interviewer (student), or interviewee (DEA)**	What numbers of people are involved?	**Student plus twelve interviewees**

What existing precautions are in place to reduce risks?		Risk level with existing precautions
✓	**Take care to ensure telephone contact can be made with Supervisor or friend/relative during interviews.**	**Low**
✓	**If driving, drive carefully, as in any other situation.**	**Low**
What additional actions are required to ensure precautions are implemented/effective or to reduce the risk further?		Risk level with additional precautions

	None	**N/A**
Is health surveillance required? **NO**	If YES, please detail:	
Who will be responsible for implementing the precautions: **Toby Gledhill**		By When: **During interview period (outlined below)**

Completed by: **Toby Gledhill** .... Signed: ....

Record of annual review: ....

Risk Rating

Increasing Consequence ↑					
	5	10	15	20	25
	4	8	12	16	20
	3	6	9	12	15
	2	4	6	8	10
	1	2	3	4	5
	Increasing Likelihood →				

17-25 Unacceptable – Stop activity and make immediate improvements/seek further advice	
10-16 Tolerable – look to improve within specified timescale	
5-9 Adequate – Look to improve at next review	
1-4 Acceptable - No further action, but ensure controls are maintained	

Guide to using the risk rating table:

Consequences	Likelihood
1 Insignificant – no injury	**1 Very unlikely** – 1 in a million chance of it happening

2 Minor – minor injuries	**2 Unlikely** – 1 in 100,000 chance of it happening
3 Moderate – up to three days absence	**3 Fairly likely** – 1 in 10,000 chance of it happening
4 Major – more than three days absence	**4 Likely** – 1 in 1,000 chance of it happening
5 Catastrophic – death or disabling	**5 Very likely** – 1 in 100 chance of it happening

Travel / Fieldwork Risk Assessment

This form should be completed in conjunction with the University Travel and Fieldwork Policy and Code of Practice.

Destination(s)	Home based interviews only, with possibility of meeting some interviewees half way/in a mutually convenient location such as motorway services/café.
Date of trip	From: Proposed: _ 10/ _ 05/ _ 2016 To: to _ 01 / _ 06 / _ 2016
Number of participants	12 plus interviewer
First Aider (where required)	Not required
Emergency Contact in School	Maxwell Control (Security) +44 (0)161 29 5 33 33 out of hours.

Potential Hazard	Existing Controls	Risk Level	Additional Controls (if existing risk level is med or above)	Risk Level
Weather conditions	**N/A**			
Terrain	N/A			
Water (tides / deep water / currents etc)	N/A			
Harmful substances (Chem or bio)	N/A			
Animals	N/A			
Danger from traffic / site vehicles	N/A			
Industrial processes / plant etc	N/A			
Transport to and from site	Potentially. Travel by car/public transport	1		

	only. No special circumstances.			
Transport on site	N/A			
Crime	N/A			
Other (please state)	N/A			

NOTE: Please use the table on the next page to determine risk levels.

For destinations with medium (or above) risk ratings from Control Risks website (http://www.hr.salford.ac.uk/safety/controlrisk/index) please attach a copy of their advice and complete the additional assessment as per the Travel and Fieldwork Policy / Code of Practice.

Completed by: Toby Gledhill Signed: ....

Record of annual review: ....

Risk Rating

Increasing Consequence ↑					
	5	10	15	20	25
	4	8	12	16	20
	3	6	9	12	15
	2	4	6	8	10
	1	2	3	4	5
	Increasing Likelihood →				

17-25 Unacceptable – Stop activity and make immediate improvements/seek further advice	
10-16 Tolerable – look to improve within specified timescale	
5-9 Adequate – Look to improve at next review	
1-4 Acceptable - No further action, but ensure controls are maintained	

Guide to using the risk rating table:

Consequences	Likelihood
1 Insignificant – no injury	**1 Very unlikely** – 1 in a million chance of it happening
2 Minor – minor injuries	**2 Unlikely** – 1 in 100,000 chance of it happening
3 Moderate – up to three days absence	**3 Fairly likely** – 1 in 10,000 chance of it happening
4 Major – more than three days absence	**4 Likely** – 1 in 1,000 chance of it happening
5 Catastrophic – death or disabling	**5 Very likely** – 1 in 100 chance of it happening

Risk Assessment, Site Based EPCs

RISK ASSESSMENT FOR RESEARCH AND PROJECTS COVER SHEET.

Student's surname	Gledhill
Student's forenames	Toby
Section of School	School of the Built Environment
Degree	Professional Doctorate
Title of Project	Case study for doctoral thesis
Brief description of the project	Energy Performance Certificate inspection and report at a control property by twenty participants, for the purpose of highlighting a level of understanding about the profession, and the wider context that surrounds the profession
Supervisor's name	Professor Will Swan
Reserve supervisor in case of absence.	Dr Richard Fitton
Locations where work will be carried out	7 Stoney Lane, Wakefield, West Yorkshire WF4 3JN Possible second residential address TBC

It is the responsibility of the PI / Supervisor to ensure the risk assessment is suitable and sufficient and that risk assessments are reviewed should any significant changes to the project / research be made.

Risk assessment (RA) tracking;

Hazard	RA required	RA complete	Risk level as identified in RA	Authorised as suitable and sufficient by supervisor
Initial Risk Assessment.	✓	✓	Low	
Physical / mechanical / electrical / animal	X	*If any of these risks are to be encountered during the research, you must complete the full Risk Assessment Form, not this one.*		
Biological – microorganisms	X			
Chemical	X			
Radiation	X			
Travel / Fieldwork	✓	✓	Low	

Host Organisation	X			

I shall be working in the establishment named below (where applicable):

Name; Toby Gledhill, W-Y-P Gledhill

Address; 7 Stoney Lane, Chapelthorpe, Wakefield WF4 3JN

Tel; 01924 249970

Emergency Contact Details.

Role	Name	Telephone & email
Student	Toby Gledhill	07889018581 toby@w-y-p.co.uk
Academic Supervisor	Will Swan	07876 580 189 W.C.Swan@salford.ac.uk
Host organisation Supervisor (where applicable)	N/A	N/A

Initial Risk Assessment.

Location:	Task/Activity/Environment:		Date of Assessment:
Identify Hazards which could cause harm:	Identify risks = what could go wrong if hazards cause harm:		
No. / Hazard	No. / Risk		
Physical / mechanical / electrical / animal	N/A		
Biological	N/A		
Chemical	N/A		
Radiation / Lasers	N/A		
Lone working	N/A		
✓ Travel / Fieldwork	**Travel to and from residential property to complete non-invasive energy performance certificate.**		
Disposal of waste material	N/A		
List groups of people who could be affected:	**Researcher (student), or participant (DEA)**	What numbers of people are involved?	**Student plus twenty participants**
What existing precautions are in place to reduce risks?			Risk level with existing precautions
✓ **Take care working at height on surveyor's (telescopic) ladders, and undertaking non-invasive domestic inspection. Researcher will be on hand to foot ladders, which are used for internal non-intrusive investigation (ie storey height, maximum) only.**			**Low**
✓ **If driving, drive with care, as in any other situation.**			**Low**
What additional actions are required to ensure precautions are implemented/effective or to reduce the risk further?			Risk level with additional precautions
None			**N/A**
Is health surveillance required? **NO**	If YES, please detail:		
Who will be responsible for implementing the precautions: **Toby Gledhill**			By When: **During case study period**

Completed by:	**Toby Gledhill**	Signed:	
Record of annual review:			

Risk Rating:

Increasing Consequence ↑					
	5	10	15	20	25
	4	8	12	16	20
	3	6	9	12	15
	2	4	6	8	10
	1	2	3	4	5
	Increasing Likelihood →				

17-25 Unacceptable – Stop activity and make immediate improvements/seek further advice
10-16 Tolerable – look to improve within specified timescale
5-9 Adequate – Look to improve at next review
1-4 Acceptable - No further action, but ensure controls are maintained

Guide to using the risk rating table:

Consequences	Likelihood
1 Insignificant – no injury	**1 Very unlikely** – 1 in a million chance of it happening
2 Minor – minor injuries	**2 Unlikely** – 1 in 100,000 chance of it happening
3 Moderate – up to three days absence	**3 Fairly likely** – 1 in 10,000 chance of it happening
4 Major – more than three days absence	**4 Likely** – 1 in 1,000 chance of it happening
5 Catastrophic – death or disabling	**5 Very likely** – 1 in 100 chance of it happening

Travel / Fieldwork Risk Assessment

This form should be completed in conjunction with the University Travel and Fieldwork Policy and Code of Practice.

Destination(s)	**7 Stoney Lane, Chapelthorpe, Wakefield WF4 3JN, plus potentially 1x other residential address, TBC.**
Date of exercise	**From:** Proposed: _ 02/ _ 01/ _ 2018 **To:** to _ 01 / _ 09 / _ 2018
Number of participants	**20 participants plus researcher**
First Aider (where required)	**Not required**
Emergency Contact in School	**Maxwell Control (Security) +44 (0)161 29 5 33 33 out of hours.**

Potential Hazard	Existing Controls	Risk Level	Additional Controls (if existing risk level is med or above)	Risk Level
Weather conditions	**N/A**			
Terrain	Normal domestic location only	1		
Water (tides / deep water / currents etc)	N/A			
Harmful substances (Chem or bio)	N/A			
Animals	N/A			
Danger from traffic / site vehicles	N/A			
Industrial processes / plant etc	N/A			
Transport to and from site	Potentially. Travel by car/public transport only. No special circumstances.	1		

Transport on site	N/A			
Crime	N/A			
Other (please state)	N/A			

NOTE: Please use the table below to determine risk levels.

For destinations with medium (or above) risk ratings from Control Risks website (http://www.hr.salford.ac.uk/safety/controlrisk/index) please attach a copy of their advice and complete the additional assessment as per the Travel and Fieldwork Policy / Code of Practice.

Completed by: Toby Gledhill Signed:

Record of annual review: ....

Risk Rating: Increasing Consequence

5	10	15	20	25
4	8	12	16	20
3	6	9	12	15
2	4	6	8	10
1	2	3	4	5

Increasing Likelihood

17-25 Unacceptable – Stop activity and make immediate improvements/seek further advice

10-16 Tolerable – look to improve within specified timescale

5-9 Adequate – Look to improve at next review

1-4 Acceptable - No further action, but ensure controls are maintained

Guide to using the risk rating table:

Consequences	**Likelihood**
1 Insignificant – no injury	**1 Very unlikely** – 1 in a million chance of it happening
2 Minor – minor injuries	**2 Unlikely** – 1 in 100,000 chance of it happening
3 Moderate – up to three days absence	**3 Fairly likely** – 1 in 10,000 chance of it happening
4 Major – more than three days absence	**4 Likely** – 1 in 1,000 chance of it happening
5 Catastrophic – death or disabling	**5 Very likely** – 1 in 100 chance of it happening

Appendix G: EPCs and EPC Inputs for DEAs 1 – 10, Test Property 1

DEA 1, EPC, Test Property 1

Energy Performance Certificate

HM Government

7, Stoney Lane, Chapelthorpe, WAKEFIELD, WF4 3JN

Dwelling type:	End-terrace house	**Reference number:**	8605-2197-6929-4126-2783
Date of assessment:	21 March 2018	**Type of assessment:**	RdSAP, existing dwelling
Date of certificate:	05 April 2018	**Total floor area:**	97 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

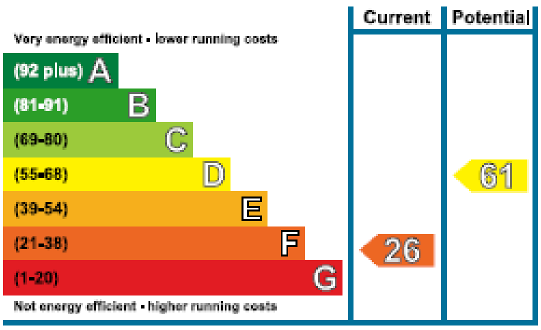
Estimated energy costs of dwelling for 3 years:	**£ 5,085**
Over 3 years you could save	**£ 1,905**

Estimated energy costs of this home

	Current costs	Potential costs	Potential future savings
Lighting	£ 288 over 3 years	£ 192 over 3 years	You could save £ 1,905 over 3 years
Heating	£ 4,296 over 3 years	£ 2,655 over 3 years	
Hot Water	£ 501 over 3 years	£ 333 over 3 years	
Totals	**£ 5,085**	**£ 3,180**	

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.

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

Recommended measures	Indicative cost	Typical savings over 3 years
1 Flat roof or sloping ceiling insulation	£850 - £1,500	£ 225
2 Internal or external wall insulation	£4,000 - £14,000	£ 1,182
3 Floor insulation (solid floor)	£4,000 - £6,000	£ 87

See page 3 for a full list of recommendations for this property.

To find out more about the recommended measures and other actions you could take today to save money, visit www.gov.uk/energy-grants-calculator or call **0300 123 1234** (standard national rate). The Green Deal may enable you to make your home warmer and cheaper to run.

Summary of this home's energy performance related features

Element	Description	Energy Efficiency
Walls	Sandstone or limestone, as built, no insulation (assumed)	★☆☆☆☆
Roof	Pitched, no insulation (assumed)	★☆☆☆☆
	Flat, no insulation (assumed)	★☆☆☆☆
Floor	Solid, no insulation (assumed)	—
Windows	Fully double glazed	★★★★☆
Main heating	Boiler and radiators, LPG	★★☆☆☆
Main heating controls	Programmer and room thermostat	★★★☆☆
Secondary heating	Room heaters, wood logs	—
Hot water	From main system	★★☆☆☆
Lighting	Low energy lighting in 50% of fixed outlets	★★★★☆

Current primary energy use per square metre of floor area: 292 kWh/m² per year

The assessment does not take into consideration the physical condition of any element. 'Assumed' means that the insulation could not be inspected and an assumption has been made in the methodology based on age and type of construction.

See addendum on the last page relating to items in the table above.

Low and zero carbon energy sources

Low and zero carbon energy sources are sources of energy that release either very little or no carbon dioxide into the atmosphere when they are used. Installing these sources may help reduce energy bills as well as cutting carbon. The following low or zero carbon energy sources are provided for this home:

- Biomass secondary heating

Your home's heat demand

For most homes, the vast majority of energy costs derive from heating the home. Where applicable, this table shows the energy that could be saved in this property by insulating the loft and walls, based on typical energy use (shown within brackets as it is a reduction in energy use).

Heat demand	Existing dwelling	Impact of loft insulation	Impact of cavity wall insulation	Impact of solid wall insulation
Space heating (kWh per year)	18,493	(2,482)	N/A	(5,766)
Water heating (kWh per year)	2,231			

You could receive Renewable Heat Incentive (RHI) payments and help reduce carbon emissions by replacing your existing heating system with one that generates renewable heat, subject to meeting minimum energy efficiency requirements. The estimated energy required for space and water heating will form the basis of the payments. For more information, search for the domestic RHI on the www.gov.uk website.

Recommendations

The measures below will improve the energy performance of your dwelling. The performance ratings after improvements listed below are cumulative; that is, they assume the improvements have been installed in the order that they appear in the table. Further information about the recommended measures and other simple actions you could take today to save money is available at www.gov.uk/energy-grants-calculator. Before installing measures, you should make sure you have secured the appropriate permissions, where necessary. Such permissions might include permission from your landlord (if you are a tenant) or approval under Building Regulations for certain types of work.

Recommended measures	Indicative cost	Typical savings per year	Rating after improvement
Flat roof or sloping ceiling insulation	£850 - £1,500	£ 75	F29
Internal or external wall insulation	£4,000 - £14,000	£ 394	E44
Floor insulation (solid floor)	£4,000 - £6,000	£ 29	E45
Low energy lighting for all fixed outlets	£40	£ 26	E46
Heating controls (thermostatic radiator valves)	£350 - £450	£ 54	E49
Solar water heating	£4,000 - £6,000	£ 57	E52
Solar photovoltaic panels, 2.5 kWp	£5,000 - £8,000	£ 271	D61

Opportunity to benefit from a Green Deal on this property

Green Deal Finance allows you to pay for some of the cost of your improvements in instalments under a Green Deal Plan (note that this is a credit agreement, but with instalments being added to the electricity bill for the property). The availability of a Green Deal Plan will depend upon your financial circumstances. There is a limit to how much Green Deal Finance can be used, which is determined by how much energy the improvements are estimated to **save** for a 'typical household'.

You may be able to obtain support towards repairs or replacements of heating systems and/or basic insulation measures, if you are in receipt of qualifying benefits or tax credits. To learn more about this scheme and the rules about eligibility, call the Energy Saving Advice Service on **0300 123 1234** for England and Wales.

About this document and the data in it

This document has been produced following an energy assessment undertaken by a qualified Energy Assessor, accredited by Elmhurst Energy Systems Ltd. You can obtain contact details of the Accreditation Scheme at www.elmhurstenergy.co.uk.

A copy of this certificate has been lodged on a national register as a requirement under the Energy Performance of Buildings Regulations 2012 as amended. It will be made available via the online search function at www.epcregister.com. The certificate (including the building address) and other data about the building collected during the energy assessment but not shown on the certificate, for instance heating system data, will be made publicly available at www.opendatacommunities.org.

This certificate and other data about the building may be shared with other bodies (including government departments and enforcement agencies) for research, statistical and enforcement purposes. For further information about how data about the property are used, please visit www.epcregister.com. To opt out of having information about your building made publicly available, please visit www.epcregister.com/optout.

Assessor's accreditation number: EES/006272
Assessor's name: Mr. Toby Gledhill
Phone number: 01924 249970
E-mail address: toby@w-y-p.co.uk
Related party disclosure: No related party

There is more information in the guidance document *Energy Performance Certificates for the marketing, sale and let of dwellings* available on the Government website at: www.gov.uk/government/collections/energy-performance-certificates. It explains the content and use of this document, advises on how to identify the authenticity of a certificate and how to make a complaint.

About the impact of buildings on the environment

One of the biggest contributors to global warming is carbon dioxide. The energy we use for heating, lighting and power in homes produces over a quarter of the UK's carbon dioxide emissions.

The average household causes about 6 tonnes of carbon dioxide every year. Based on this assessment, your home currently produces approximately 5.5 tonnes of carbon dioxide every year. Adopting the recommendations in this report can reduce emissions and protect the environment. If you were to install these recommendations you could reduce this amount by 3.0 tonnes per year. You could reduce emissions even more by switching to renewable energy sources.

The environmental impact rating is a measure of a home's impact on the environment in terms of carbon dioxide (CO_2) emissions based on standardised assumptions about occupancy and energy use. The higher the rating the less impact it has on the environment.

Addendum

This dwelling has stone walls and so requires further investigation to establish whether these walls are of cavity construction and to determine which type of cavity wall insulation is best suited.

DEA 1, EPC Inputs, Test Property 1

RdSAP

elmhurst energy systems

Summary Information

Surveyor:	C300-0001				
Name:	Toby Gledhill		Title: Mr.	**Tel Number:**	
Survey Reference:	000250		**My Reference:**		
Current SAP rating:	F 26	**Potential SAP rating:**	D 61	**Emissions (t/year):**	5.466 tonnes
Current EI rating:	E 49	**Potential EI rating:**	C 77	**Fuel Bill:**	£1694

Property Details:

RdSAP version:	SAP 9.93
Reference Number:	C300-0001-000250
My Reference:	
Lodgement Required:	Yes
Regs Region:	England
EPC Language:	English
UPRN:	2561619768
Postcode:	WF4 3JN
Region:	East Pennines
House Name:	
House No:	7
Street:	Stoney Lane
Locality:	Chapelthorpe
Town:	WAKEFIELD
County:	West Yorkshire
Property Tenure:	Owner-occupied
Transaction Type:	None of the above
Inspection Date:	21/03/2018
Process date:	05/04/2018

RdSAP Inputs

Property Description:

1.0 Property type:		H House E End-Terrace
2.0 Number of	**Storeys:**	2
	Habitable Rooms:	5
	Heated Habitable Rooms:	4
3.0 Date Built	**Main Property**	A before 1900
	1st Extension	D 1950-1966

4.0 Dimensions:

Dimension type: **Internal**

	Floor Area [m2]	Room Height [m]	Heat Loss Wall Perimeter [m]	Party Wall Length [m]
Main Property				
1st Floor:	32.16	2.30	13.52	5.73
Lowest Floor:	26.44	2.06	12.30	4.73
1st Extension				
1st Floor:	13.91	2.30	11.11	0.00
Lowest Floor:	13.91	2.14	3.65	3.65

5.0 Conservatory:

Is there a conservatory?	Yes
Is it thermally separated?	No
Floor Area [m2]	10.35
Double Glazed	Yes
Glazed Perimeter [m]	3.36
Room Height	1 Storey

7.0 Walls:

Main Property

Type	SS Stone: sandstone or limestone
Insulation	A As Built
Dry-lining	No
Wall Thickness Unknown	No
Wall Thickness [mm]	500
U-value Known	No
Party Wall Type	U Unable to determine

Summary Information

1st Extension

As Main Wall	No
Type	SS Stone: sandstone or limestone
Insulation	A As Built
Dry-lining	No
Wall Thickness Unknown	No
Wall Thickness [mm]	360
U-value Known	No
Party Wall Type	U Unable to determine

8.0 Roofs:

Main Property

Type	PN Pitched (slates/tiles), no access
Insulation	U Unknown
U-value Known	No

1st Extension

As Main	No
Type	F Flat
Insulation Thickness	As Built
U-value Known	No

9.0 Floors:

Main Property

Location	G Ground floor
Type	S Solid
Insulation	A As built
U-value Known	No

1st Extension

As Main	No
Location	G Ground floor
Type	U Unknown
Insulation	A As built
U-value Known	No

10.0 Doors:

Total Number of Doors	1
Number of Insulated Doors	0

11.0 Windows:

Glazed Area	T Typical
Proportion Double\Triple-glazed	100 %
Glazing	Double post or during 2002
Draught Proofing	91 %

12.0 Ventilation & Cooling

No. of open Fireplaces	0
Mechanical Ventilation	No
Fixed Space Cooling	No

13.0 Lighting

Total number of light fittings	16
Total number of L.E.L. fittings	8

14.0 Main Heating1

PCDF boiler Reference	16844 Vaillant, ecoTEC pro 28, 90.30%
Main Heating Code	BLW Post 98 Combi condens. with auto ign.
Heat Emitter	Radiators
Heat pump age	Unknown
Fuel Type	Bulk LPG
Flue Type	Balanced
Fan Assisted Flue	Yes
Design flow temperature	Unknown
PCDF Heating Controls	0
Main Heating Controls	CBC Programmer and room thermostat
PCDF Compensator	0
Percentage of Heat	100 %

RdSAP

elmhurst energy systems

Summary Information

14.1 Main Heating2

PCDF boiler Reference	0
Main Heating Code	
Percentage of Heat	0 %
Secondary Heating Code	RWM Closed room heater

15.0 Water Heating

Water Heating Code	HWP From the primary heating system

15.1 Hot Water Cylinder

Hot Water Cylinder Present	No

16.0 Solar water heating

Solar Water Heating	No

17.0 Waste Water Heat Recovery System

Total Number of rooms with bath and/or shower	1
Number of rooms with mixer shower and no bath	0
Number of rooms with bath and mixer shower	1
Is WWHRS present in the property?	No / Unknown

18.0 Flue Gas Heat Recovery System

Present	No

19.0 Photovoltaic Panel

Photovoltaic Panel	None

20.0 Wind Turbine

Terrain Type	Suburban
Wind turbine present?	No

21.0 Other Details

Electricity meter type	Single
Main gas	Yes

RdSAP

elmhurst energy systems

Summary Information

Recommendations

- Loft insulation (Not applicable)
- Flat roof insulation (Recommended)
- Room-in-roof insulation (Not applicable)
- Cavity wall insulation (Not applicable)
- Party wall insulation (Not applicable)
- Solid wall insulation (Recommended)
- Floor insulation (solid floor) (Recommended)
- Hot water cylinder insulation (Not applicable)
- Draught proofing (SAP increase too small)
- Low energy lighting (Recommended)
- Cylinder thermostat (Not applicable)
- Heating controls for wet central heating system (Recommended)
- Upgrade boiler, same fuel (Already installed)
- Change heating to condensing gas condensing boiler (fuel switch) (Not applicable)
- Flue gas heat recovery in conjunction with new boiler (Not applicable)
- Solar water heating (Recommended)
- Heat recovery system for mixer showers (SAP increase too small)
- Double glazed windows (Already installed)
- Insulated doors (SAP increase too small)
- Solar photovoltaic panels (Recommended)
- Wind turbine (Not applicable)

Alternative Recommendations

- External wall insulation with cavity insulation (Not applicable)
- Biomass boiler (alternative) (Not applicable)
- Air or ground source heat pump (alternative) (Not applicable)
- Air or ground source heat pump with underfloor heating (alternative) (Not applicable)
- Micro CHP (alternative) (Not applicable)

Related Party Disclosure

Addenda

— **Any Wall Insulation Issues** —

Has the property any 'Access Issues' for potential wall insulation?	No
Is the property in a 'high exposure' location?	No

DEA 2, EPC, Test Property 1

Energy Performance Certificate

HM Government

7, Stoney Lane, Chapelthorpe, WAKEFIELD, WF4 3JN

Dwelling type:	End-terrace house	**Reference number:**	0275-2892-6196-9198-3661
Date of assessment:	12 January 2018	**Type of assessment:**	RdSAP, existing dwelling
Date of certificate:	25 January 2018	**Total floor area:**	94 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

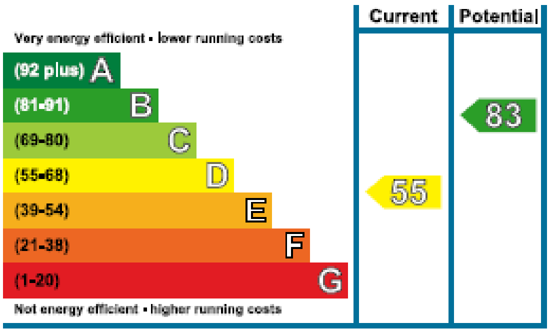
Estimated energy costs of dwelling for 3 years:	**£ 3,561**
Over 3 years you could save	**£ 1,470**

Estimated energy costs of this home

	Current costs	Potential costs	Potential future savings
Lighting	£ 240 over 3 years	£ 240 over 3 years	**You could save £ 1,470 over 3 years**
Heating	£ 3,009 over 3 years	£ 1,632 over 3 years	
Hot Water	£ 312 over 3 years	£ 219 over 3 years	
Totals	**£ 3,561**	**£ 2,091**	

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.

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

Recommended measures	Indicative cost	Typical savings over 3 years
1 Flat roof or sloping ceiling insulation	£850 - £1,500	£ 582
2 Cavity wall insulation	£500 - £1,500	£ 96
3 Internal or external wall insulation	£4,000 - £14,000	£ 615

See page 3 for a full list of recommendations for this property.

To find out more about the recommended measures and other actions you could take today to save money, visit www.gov.uk/energy-grants-calculator or call **0300 123 1234** (standard national rate). The Green Deal may enable you to make your home warmer and cheaper to run.

Summary of this home's energy performance related features

Element	Description	Energy Efficiency
Walls	Sandstone or limestone, as built, no insulation (assumed)	★☆☆☆☆
	Cavity wall, as built, no insulation (assumed)	★★☆☆☆
Roof	Pitched, no insulation (assumed)	★☆☆☆☆
	Flat, no insulation (assumed)	★☆☆☆☆
	Pitched, insulated (assumed)	★★★★☆
Floor	Solid, no insulation (assumed)	—
	To external air, no insulation (assumed)	—
	Solid, insulated (assumed)	—
Windows	Fully double glazed	★★★☆☆
Main heating	Boiler and radiators, mains gas	★★★★☆
Main heating controls	Programmer and room thermostat	★★★☆☆
Secondary heating	Room heaters, dual fuel (mineral and wood)	—
Hot water	From main system	★★★★☆
Lighting	Low energy lighting in 86% of fixed outlets	★★★★★

Current primary energy use per square metre of floor area: 328 kWh/m² per year

The assessment does not take into consideration the physical condition of any element. 'Assumed' means that the insulation could not be inspected and an assumption has been made in the methodology based on age and type of construction.

See addendum on the last page relating to items in the table above.

Low and zero carbon energy sources

Low and zero carbon energy sources are sources of energy that release either very little or no carbon dioxide into the atmosphere when they are used. Installing these sources may help reduce energy bills as well as cutting carbon. There are none provided for this home.

Your home's heat demand

For most homes, the vast majority of energy costs derive from heating the home. Where applicable, this table shows the energy that could be saved in this property by insulating the loft and walls, based on typical energy use (shown within brackets as it is a reduction in energy use).

Heat demand	Existing dwelling	Impact of loft insulation	Impact of cavity wall insulation	Impact of solid wall insulation
Space heating (kWh per year)	18,578	N/A	(588)	(3,667)
Water heating (kWh per year)	2,220			

You could receive Renewable Heat Incentive (RHI) payments and help reduce carbon emissions by replacing your existing heating system with one that generates renewable heat, subject to meeting minimum energy efficiency requirements. The estimated energy required for space and water heating will form the basis of the payments. For more information, search for the domestic RHI on the www.gov.uk website.

Recommendations

The measures below will improve the energy performance of your dwelling. The performance ratings after improvements listed below are cumulative; that is, they assume the improvements have been installed in the order that they appear in the table. Further information about the recommended measures and other simple actions you could take today to save money is available at www.gov.uk/energy-grants-calculator. Before installing measures, you should make sure you have secured the appropriate permissions, where necessary. Such permissions might include permission from your landlord (if you are a tenant) or approval under Building Regulations for certain types of work.

Recommended measures	Indicative cost	Typical savings per year	Rating after improvement
Flat roof or sloping ceiling insulation	£850 - £1,500	£ 194	D62
Cavity wall insulation	£500 - £1,500	£ 32	D63
Internal or external wall insulation	£4,000 - £14,000	£ 205	C71
Floor insulation (solid floor)	£4,000 - £6,000	£ 27	C72
Solar water heating	£4,000 - £6,000	£ 32	C73
Solar photovoltaic panels, 2.5 kWp	£5,000 - £8,000	£ 285	B83

Alternative measures

There are alternative measures below which you could also consider for your home.

- External insulation with cavity wall insulation

Opportunity to benefit from a Green Deal on this property

Green Deal Finance allows you to pay for some of the cost of your improvements in instalments under a Green Deal Plan (note that this is a credit agreement, but with instalments being added to the electricity bill for the property). The availability of a Green Deal Plan will depend upon your financial circumstances. There is a limit to how much Green Deal Finance can be used, which is determined by how much energy the improvements are estimated to **save** for a 'typical household'.

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Assessor's accreditation number:	EES/006272
Assessor's name:	Mr. Toby Gledhill
Phone number:	01924 249970
E-mail address:	toby@w-y-p.co.uk
Related party disclosure:	No related party

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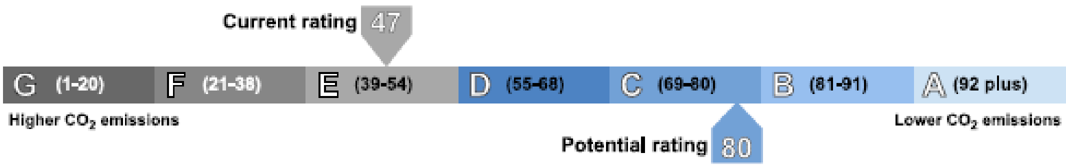


Addendum

This dwelling has stone walls and so requires further investigation to establish whether these walls are of cavity construction and to determine which type of cavity wall insulation is best suited.

DEA 2, EPC Inputs, Test Property 1

RdSAP elmhurst energy systems

Summary Information

Surveyor:	C300-0001				
Name:	Toby Gledhill	Title: Mr.		Tel Number:	
Survey Reference:	000227	My Reference:			
Current SAP rating:	D 55	Potential SAP rating:	B 83	Emissions (t/year):	5.603 tonnes
Current EI rating:	E 47	Potential EI rating:	C 80	Fuel Bill:	£1187

Property Details:

RdSAP version:	SAP 9.93
Reference Number:	C300-0001-000227
My Reference:	
Lodgement Required:	Yes
Regs Region:	England
EPC Language:	English
UPRN:	2561619768
Postcode:	WF4 3JN
Region:	East Pennines
House Name:	
House No:	7
Street:	Stoney Lane
Locality:	Chapelthorpe
Town:	WAKEFIELD
County:	West Yorkshire
Property Tenure:	Owner-occupied
Transaction Type:	None of the above
Inspection Date:	12/01/2018
Process date:	25/01/2018

RdSAP Inputs

Property Description:

1.0 Property type:		H House
		E End-Terrace
2.0 Number of	Storeys:	2
	Habitable Rooms:	4
	Heated Habitable Rooms:	4
3.0 Date Built:	Main Property	A before 1900
	1st Extension	A before 1900
	2nd Extension	D 1950-1966
	3rd Extension	J 2003-2006

4.0 Dimensions:

Dimension type: Internal

Main Property	Floor Area [m2]	Room Height [m]	Heat Loss Wall Perimeter [m]	Party Wall Length [m]
1st Floor:	26.43	2.67	6.85	5.26
Lowest Floor:	26.43	2.25	11.56	5.26
1st Extension				
1st Floor:	0.00	0.00	0.00	0.00
Lowest Floor:	5.58	2.67	7.08	0.00
2nd Extension				
1st Floor:	12.42	2.27	7.07	3.25
Lowest Floor:	12.42	2.14	3.31	3.25
3rd Extension				
1st Floor:	0.00	0.00	0.00	0.00
Lowest Floor:	10.98	2.51	2.90	6.84

RdSAP elmhurst energy

elmhurst energy systems

Summary Information

5.0 Conservatory:

Is there a conservatory?	No

7.0 Walls:

Main Property

Type	SS Stone: sandstone or limestone
Insulation	A As Built
Dry-lining	No
Wall Thickness Unknown	No
Wall Thickness [mm]	450
U-value Known	No
Party Wall Type	U Unable to determine

1st Extension

As Main Wall	Yes
Type	SS Stone: sandstone or limestone
Insulation	A As Built
Dry-lining	No
Wall Thickness Unknown	No
Wall Thickness [mm]	450
U-value Known	No

2nd Extension

As Main Wall	No
Type	CA Cavity
Insulation	A As Built
Dry-lining	No
Wall Thickness Unknown	No
Wall Thickness [mm]	315
U-value Known	No
Party Wall Type	U Unable to determine

3rd Extension

As Main Wall	No
Type	SO Solid Brick
Insulation	A As Built
Wall Thickness Unknown	No
Wall Thickness [mm]	190
U-value Known	No
Party Wall Type	U Unable to determine

8.0 Roofs:

Main Property

Type	PS Pitched, sloping ceiling
Insulation Thickness	As Built
U-value Known	No

1st Extension

As Main	Yes
Type	PS Pitched, sloping ceiling
Insulation Thickness	As Built
U-value Known	No

2nd Extension

As Main	No
Type	F Flat
Insulation Thickness	As Built
U-value Known	No

3rd Extension

As Main	No
Type	PS Pitched, sloping ceiling
Insulation Thickness	As Built
U-value Known	No

Summary Information

14.1 Main Heating2

PCDF boiler Reference	0
Main Heating Code	
Percentage of Heat	0 %
Secondary Heating Code	RDM Closed room heater

15.0 Water Heating

Water Heating Code	HWP From the primary heating system

15.1 Hot Water Cylinder

Hot Water Cylinder Present	No

16.0 Solar water heating

Solar Water Heating	No

17.0 Waste Water Heat Recovery System

Total Number of rooms with bath and/or shower	1
Number of rooms with mixer shower and no bath	0
Number of rooms with bath and mixer shower	1
Is WWHRS present in the property?	No / Unknown

18.0 Flue Gas Heat Recovery System

Present	No

19.0 Photovoltaic Panel

Photovoltaic Panel	None

20.0 Wind Turbine

Terrain Type	Suburban
Wind turbine present?	No

21.0 Other Details

Electricity meter type	Dual
Main gas	Yes

RdSAP

elmhurst energy systems

Summary Information

9.0 Floors:

Main Property

Location	G Ground floor
Type	S Solid
Insulation	A As built
U-value Known	No

1st Extension

As Main	No
Location	E To external air
Type	T Suspended timber
Insulation	A As built
U-value Known	No

2nd Extension

As Main	Yes
Location	G Ground floor
Type	S Solid
Insulation	A As built
U-value Known	No

3rd Extension

As Main	Yes
Location	G Ground floor
Type	S Solid
Insulation	A As built
U-value Known	No

10.0 Doors:

Total Number of Doors	1
Number of Insulated Doors	0

11.0 Windows:

Glazed Area	T Typical
Proportion Double\Triple-glazed	100 %
Glazing	Double with unknown install date
Frame Type	PVC frame
Glazing Gap	12 mm
Draught Proofing	100 %

12.0 Ventilation & Cooling

No. of open Fireplaces	0
Mechanical Ventilation	No
Fixed Space Cooling	No

13.0 Lighting

Total number of light fittings	14
Total number of L.E.L. fittings	12

14.0 Main Heating1

PCDF boiler Reference	10328 Vaillant, Ecotec Pro, 88.80%
Main Heating Code	BGW Post 98 Combi condens. with auto ign.
Heat Emitter	Radiators
Heat pump age	Unknown
Fuel Type	Mains gas
Flue Type	Balanced
Fan Assisted Flue	Yes
Design flow temperature	Unknown
PCDF Heating Controls	0
Main Heating Controls	CBC Programmer and room thermostat
PCDF Compensator	0
Percentage of Heat	100 %

RdSAP

elmhurst energy systems

Summary Information

Recommendations

- Loft insulation (Not applicable)
- Flat roof insulation (Recommended)
- Room-in-roof insulation (Not applicable)
- Cavity wall insulation (Recommended)
- Party wall insulation (Not applicable)
- Solid wall insulation (Recommended)
- Floor insulation (solid floor) (Recommended)
- Hot water cylinder insulation (Not applicable)
- Draught proofing (Already installed)
- Low energy lighting (SAP increase too small)
- Cylinder thermostat (Not applicable)
- Heating controls for wet central heating system (SAP increase too small)
- Upgrade boiler, same fuel (Already installed)
- Change heating to condensing gas condensing boiler (fuel switch) (Not applicable)
- Flue gas heat recovery in conjunction with new boiler (Not applicable)
- Solar water heating (Recommended)
- Heat recovery system for mixer showers (SAP increase too small)
- Double glazed windows (Already installed)
- Insulated doors (SAP increase too small)
- Solar photovoltaic panels (Recommended)
- Wind turbine (Not applicable)

Alternative Recommendations

External wall insulation with cavity insulation (Alternative measure)
Biomass boiler (alternative) (Not applicable)
Air or ground source heat pump (alternative) (Not applicable)
Air or ground source heat pump with underfloor heating (alternative) (Not applicable)
Micro CHP (alternative) (Not applicable)

Related Party Disclosure

No related party

Addenda

— Any Wall Insulation Issues —

, Cavity wall insulation recommended (Ext2)Stone walls are present (, MainExt1)

Has the property any 'Access Issues' for potential wall insulation?	No
Has the property any 'narrow cavity(s)' (<50mm)?	No
Is the property in a 'high exposure' location?	No

DEA 3, EPC, Test Property 1

Energy Performance Certificate

HM Government

7, Stoney Lane, Chapelthorpe, WAKEFIELD, WF4 3JN

Dwelling type:	End-terrace house	**Reference number:**	2248-2016-6269-7198-1954
Date of assessment:	24 January 2018	**Type of assessment:**	RdSAP, existing dwelling
Date of certificate:	02 May 2018	**Total floor area:**	93 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

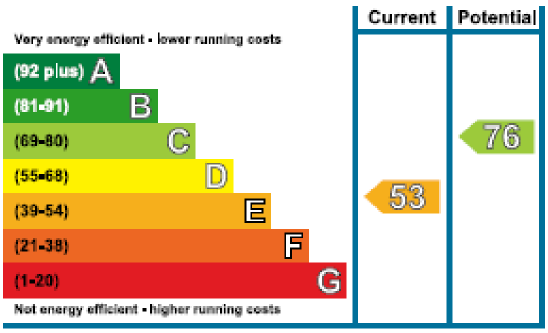
Estimated energy costs of dwelling for 3 years:	**£ 3,645**
Over 3 years you could save	**£ 1,077**

Estimated energy costs of this home

	Current costs	Potential costs	Potential future savings
Lighting	£ 348 over 3 years	£ 186 over 3 years	You could save £ 1,077 over 3 years
Heating	£ 2,988 over 3 years	£ 2,166 over 3 years	
Hot Water	£ 309 over 3 years	£ 216 over 3 years	
Totals	**£ 3,645**	**£ 2,568**	

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.

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

Recommended measures	Indicative cost	Typical savings over 3 years
1 Flat roof or sloping ceiling insulation	£850 - £1,500	£ 141
2 Cavity wall insulation	£500 - £1,500	£ 129
3 Internal or external wall insulation	£4,000 - £14,000	£ 570

See page 3 for a full list of recommendations for this property.

To find out more about the recommended measures and other actions you could take today to save money, visit www.gov.uk/energy-grants-calculator or call **0300 123 1234** (standard national rate). The Green Deal may enable you to make your home warmer and cheaper to run.

Summary of this home's energy performance related features

Element	Description	Energy Efficiency
Walls	Granite or whinstone, as built, no insulation (assumed)	★☆☆☆☆
	Cavity wall, as built, no insulation (assumed)	★★☆☆☆
Roof	Pitched, no insulation (assumed)	★☆☆☆☆
	Flat, no insulation (assumed)	★☆☆☆☆
Floor	Solid, no insulation (assumed)	—
Windows	Fully double glazed	★★★☆☆
Main heating	Boiler and radiators, mains gas	★★★★☆
Main heating controls	Programmer, room thermostat and TRVs	★★★★☆
Secondary heating	Room heaters, wood logs	—
Hot water	From main system	★★★★☆
Lighting	Low energy lighting in 13% of fixed outlets	★★☆☆☆

Current primary energy use per square metre of floor area: 341 kWh/m² per year

The assessment does not take into consideration the physical condition of any element. 'Assumed' means that the insulation could not be inspected and an assumption has been made in the methodology based on age and type of construction.

See addendum on the last page relating to items in the table above.

Low and zero carbon energy sources

Low and zero carbon energy sources are sources of energy that release either very little or no carbon dioxide into the atmosphere when they are used. Installing these sources may help reduce energy bills as well as cutting carbon. The following low or zero carbon energy sources are provided for this home:

- Biomass secondary heating

Your home's heat demand

For most homes, the vast majority of energy costs derive from heating the home. Where applicable, this table shows the energy that could be saved in this property by insulating the loft and walls, based on typical energy use (shown within brackets as it is a reduction in energy use).

Heat demand	Existing dwelling	Impact of loft insulation	Impact of cavity wall insulation	Impact of solid wall insulation
Space heating (kWh per year)	18,399	(2,663)	(896)	(4,037)
Water heating (kWh per year)	2,213			

You could receive Renewable Heat Incentive (RHI) payments and help reduce carbon emissions by replacing your existing heating system with one that generates renewable heat, subject to meeting minimum energy efficiency requirements. The estimated energy required for space and water heating will form the basis of the payments. For more information, search for the domestic RHI on the www.gov.uk website.

Recommendations

The measures below will improve the energy performance of your dwelling. The performance ratings after improvements listed below are cumulative; that is, they assume the improvements have been installed in the order that they appear in the table. Further information about the recommended measures and other simple actions you could take today to save money is available at www.gov.uk/energy-grants-calculator. Before installing measures, you should make sure you have secured the appropriate permissions, where necessary. Such permissions might include permission from your landlord (if you are a tenant) or approval under Building Regulations for certain types of work.

Recommended measures	Indicative cost	Typical savings per year	Rating after improvement
Flat roof or sloping ceiling insulation	£850 - £1,500	£ 47	D55
Cavity wall insulation	£500 - £1,500	£ 43	D56
Internal or external wall insulation	£4,000 - £14,000	£ 190	D63
Low energy lighting for all fixed outlets	£65	£ 47	D65
Solar water heating	£4,000 - £6,000	£ 32	D66
Solar photovoltaic panels, 2.5 kWp	£5,000 - £8,000	£ 271	C76

Alternative measures

There are alternative measures below which you could also consider for your home.

- External insulation with cavity wall insulation

Opportunity to benefit from a Green Deal on this property

Green Deal Finance allows you to pay for some of the cost of your improvements in instalments under a Green Deal Plan (note that this is a credit agreement, but with instalments being added to the electricity bill for the property). The availability of a Green Deal Plan will depend upon your financial circumstances. There is a limit to how much Green Deal Finance can be used, which is determined by how much energy the improvements are estimated to **save** for a 'typical household'.

You may be able to obtain support towards repairs or replacements of heating systems and/or basic insulation measures, if you are in receipt of qualifying benefits or tax credits. To learn more about this scheme and the rules about eligibility, call the Energy Saving Advice Service on **0300 123 1234** for England and Wales.

About this document and the data in it

This document has been produced following an energy assessment undertaken by a qualified Energy Assessor, accredited by Elmhurst Energy Systems Ltd. You can obtain contact details of the Accreditation Scheme at www.elmhurstenergy.co.uk.

A copy of this certificate has been lodged on a national register as a requirement under the Energy Performance of Buildings Regulations 2012 as amended. It will be made available via the online search function at www.epcregister.com. The certificate (including the building address) and other data about the building collected during the energy assessment but not shown on the certificate, for instance heating system data, will be made publicly available at www.opendatacommunities.org.

This certificate and other data about the building may be shared with other bodies (including government departments and enforcement agencies) for research, statistical and enforcement purposes. Any personal data it contains will be processed in accordance with the General Data Protection Regulation and all applicable laws and regulations relating to the processing of personal data and privacy. For further information about this and how data about the property are used, please visit www.epcregister.com. To opt out of having information about your building made publicly available, please visit www.epcregister.com/optout.

Assessor's accreditation number:	EES/006272
Assessor's name:	Mr. Toby Gledhill
Phone number:	01924 249970
E-mail address:	toby@w-y-p.co.uk
Related party disclosure:	No related party

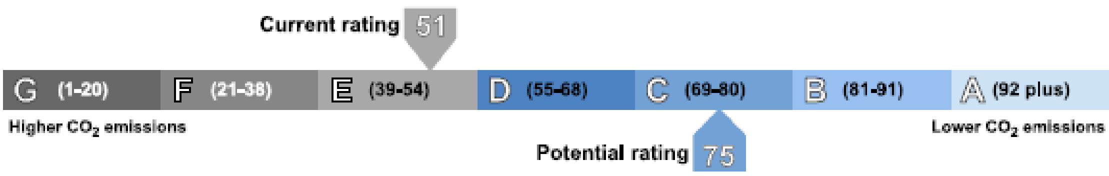
There is more information in the guidance document *Energy Performance Certificates for the marketing, sale and let of dwellings* available on the Government website at: www.gov.uk/government/collections/energy-performance-certificates. It explains the content and use of this document, advises on how to identify the authenticity of a certificate and how to make a complaint.

About the impact of buildings on the environment

One of the biggest contributors to global warming is carbon dioxide. The energy we use for heating, lighting and power in homes produces over a quarter of the UK's carbon dioxide emissions.

The average household causes about 6 tonnes of carbon dioxide every year. Based on this assessment, your home currently produces approximately 5.1 tonnes of carbon dioxide every year. Adopting the recommendations in this report can reduce emissions and protect the environment. If you were to install these recommendations you could reduce this amount by 2.5 tonnes per year. You could reduce emissions even more by switching to renewable energy sources.

The environmental impact rating is a measure of a home's impact on the environment in terms of carbon dioxide (CO_2) emissions based on standardised assumptions about occupancy and energy use. The higher the rating the less impact it has on the environment.



Addendum

This dwelling has stone walls and so requires further investigation to establish whether these walls are of cavity construction and to determine which type of cavity wall insulation is best suited.

DEA 3, EPC Inputs, Test Property 1

RdSAP elmhurst energy systems

Summary Information

Surveyor:	C300-0001				
Name:	Toby Gledhill	**Title:** Mr.		**Tel Number:**	
Survey Reference:	000259	**My Reference:**			
Current SAP rating:	E 53	**Potential SAP rating:**	C 76	**Emissions (t/year):**	5.060 tonnes
Current EI rating:	E 51	**Potential EI rating:**	C 75	**Fuel Bill:**	£1215

Property Details:

RdSAP version:	SAP 9.93
Reference Number:	C300-0001-000259
My Reference:	
Lodgement Required:	Yes
Regs Region:	England
EPC Language:	English
UPRN:	2561619768
Postcode:	WF4 3JN
Region:	East Pennines
House Name:	
House No:	7
Street:	Stoney Lane
Locality:	Chapelthorpe
Town:	WAKEFIELD
County:	West Yorkshire
Property Tenure:	Owner-occupied
Transaction Type:	None of the above
Inspection Date:	24/01/2018
Process date:	02/05/2018

RdSAP Inputs

Property Description:

1.0 Property type:		H House E End-Terrace
2.0 Number of	**Storeys:**	2
	Habitable Rooms:	4
	Heated Habitable Rooms:	4
3.0 Date Built:	**Main Property**	A before 1900
	1st Extension	D 1950-1966

4.0 Dimensions:

Dimension type: Internal

	Floor Area [m2]	Room Height [m]	Heat Loss Wall Perimeter [m]	Party Wall Length [m]
Main Property				
1st Floor:	31.62	2.50	14.15	5.60
Lowest Floor:	26.09	2.25	11.52	4.65
1st Extension				
1st Floor:	11.70	2.10	11.00	0.00
Lowest Floor:	11.70	2.10	3.60	3.60

5.0 Conservatory:

Is there a conservatory?	Yes
Is it thermally separated?	No
Floor Area [m2]	11.50
Double Glazed	Yes
Glazed Perimeter [m]	3.05
Room Height	1 Storey

7.0 Walls:

Main Property

Type	SG Stone: granite or whinstone
Insulation	A As Built
Dry-lining	No
Wall Thickness Unknown	No
Wall Thickness [mm]	480
U-value Known	No
Party Wall Type	U Unable to determine

RdSAP

elmhurst energy systems

Summary Information

1st Extension

As Main Wall	No
Type	CA Cavity
Insulation	A As Built
Dry-lining	No
Wall Thickness Unknown	No
Wall Thickness [mm]	350
U-value Known	No
Party Wall Type	U Unable to determine

8.0 Roofs:

Main Property

Type	PN Pitched (slates/tiles), no access
Insulation	U Unknown
U-value Known	No

1st Extension

As Main	No
Type	F Flat
Insulation Thickness	As Built
U-value Known	No

9.0 Floors:

Main Property

Location	G Ground floor
Type	S Solid
Insulation	A As built
U-value Known	No

1st Extension

As Main	Yes
Location	G Ground floor
Type	S Solid
Insulation	A As built
U-value Known	No

10.0 Doors:

Total Number of Doors	2
Number of Insulated Doors	0

11.0 Windows:

Glazed Area	T Typical
Proportion Double\Triple-glazed	100 %
Glazing	Double pre 2002
Frame Type	PVC frame
Glazing Gap	6 mm
Draught Proofing	56 %

12.0 Ventilation & Cooling

No. of open Fireplaces	0
Mechanical Ventilation	No
Fixed Space Cooling	No

13.0 Lighting

Total number of light fittings	15
Total number of L.E.L. fittings	2

14.0 Main Heating1

PCDF boiler Reference	10328 Vaillant, Ecotec Pro, 88.80%
Main Heating Code	BGW Post 98 Combi condens. with auto ign.
Heat Emitter	Radiators
Heat pump age	Unknown
Fuel Type	Mains gas
Flue Type	Balanced
Fan Assisted Flue	Yes
Design flow temperature	Unknown
PCDF Heating Controls	0
Main Heating Controls	CBE Programmer, room thermostat and TRVs
PCDF Compensator	0
Percentage of Heat	100 %

Summary Information

14.1 Main Heating2

PCDF boiler Reference	0
Main Heating Code	
Percentage of Heat	0 %
Secondary Heating Code	RWM Closed room heater

15.0 Water Heating

Water Heating Code	HWP From the primary heating system

15.1 Hot Water Cylinder

Hot Water Cylinder Present	No

16.0 Solar water heating

Solar Water Heating	No

17.0 Waste Water Heat Recovery System

Total Number of rooms with bath and/or shower	1
Number of rooms with mixer shower and no bath	0
Number of rooms with bath and mixer shower	1
Is WWHRS present in the property?	No / Unknown

18.0 Flue Gas Heat Recovery System

Present	No

19.0 Photovoltaic Panel

Photovoltaic Panel	None

20.0 Wind Turbine

Terrain Type	Suburban
Wind turbine present?	No

21.0 Other Details

Electricity meter type	Single
Main gas	Yes

RdSAP elmhurst energy systems

Summary Information

Recommendations

- Loft insulation (Not applicable)
- Flat roof insulation (Recommended)
- Room-in-roof insulation (Not applicable)
- Cavity wall insulation (Recommended)
- Party wall insulation (Not applicable)
- Solid wall insulation (Recommended)
- Floor insulation (solid floor) (SAP increase too small)
- Hot water cylinder insulation (Not applicable)
- Draught proofing (SAP increase too small)
- Low energy lighting (Recommended)
- Cylinder thermostat (Not applicable)
- Heating controls for wet central heating system (Already installed)
- Upgrade boiler, same fuel (Already installed)
- Change heating to condensing gas condensing boiler (fuel switch) (Not applicable)
- Flue gas heat recovery in conjunction with new boiler (Not applicable)
- Solar water heating (Recommended)
- Heat recovery system for mixer showers (SAP increase too small)
- Double glazed windows (Already installed)
- Insulated doors (SAP increase too small)
- Solar photovoltaic panels (Recommended)
- Wind turbine (Not applicable)

Alternative Recommendations

- External wall insulation with cavity insulation (Alternative measure)
- Biomass boiler (alternative) (Not applicable)
- Air or ground source heat pump (alternative) (Not applicable)
- Air or ground source heat pump with underfloor heating (alternative) (Not applicable)
- Micro CHP (alternative) (Not applicable)

Related Party Disclosure

No related party

Addenda

— **Any Wall Insulation Issues** —

, Cavity wall insulation recommended (Ext1)Stone walls are present (Main)

Has the property any 'Access Issues' for potential wall insulation?	No
Has the property any 'narrow cavity(s)' (<50mm)?	No
Is the property in a 'high exposure' location?	No

DEA 4, EPC, Test Property 1

Energy Performance Certificate

HM Government

7, Stoney Lane, Chapelthorpe, WAKEFIELD, WF4 3JN

Dwelling type:	End-terrace house	**Reference number:**	8628-6129-7160-5933-6992
Date of assessment:	17 January 2018	**Type of assessment:**	RdSAP, existing dwelling
Date of certificate:	23 January 2018	**Total floor area:**	93 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

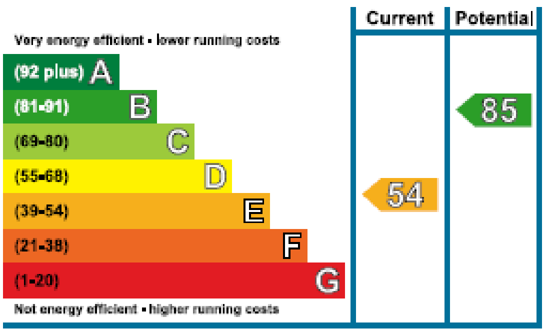
Estimated energy costs of dwelling for 3 years:	**£ 3,627**
Over 3 years you could save	**£ 1,770**

Estimated energy costs of this home

	Current costs	Potential costs	Potential future savings
Lighting	£ 300 over 3 years	£ 186 over 3 years	**You could save £ 1,770 over 3 years**
Heating	£ 3,015 over 3 years	£ 1,455 over 3 years	
Hot Water	£ 312 over 3 years	£ 216 over 3 years	
Totals	**£ 3,627**	**£ 1,857**	

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.

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

Recommended measures	Indicative cost	Typical savings over 3 years
1 Flat roof or sloping ceiling insulation	£850 - £1,500	£ 543
2 Cavity wall insulation	£500 - £1,500	£ 165
3 Internal or external wall insulation	£4,000 - £14,000	£ 519

See page 3 for a full list of recommendations for this property.

To find out more about the recommended measures and other actions you could take today to save money, visit www.gov.uk/energy-grants-calculator or call **0300 123 1234** (standard national rate). The Green Deal may enable you to make your home warmer and cheaper to run.

Summary of this home's energy performance related features

Element	Description	Energy Efficiency
Walls	Granite or whinstone, as built, no insulation (assumed)	★☆☆☆☆
	Cavity wall, as built, no insulation (assumed)	★★☆☆☆
Roof	Pitched, no insulation (assumed)	★☆☆☆☆
	Flat, no insulation (assumed)	★☆☆☆☆
Floor	Solid, no insulation (assumed)	—
	To external air, no insulation (assumed)	—
Windows	Fully double glazed	★★★☆☆
Main heating	Boiler and radiators, mains gas	★★★★☆
Main heating controls	Programmer and room thermostat	★★★☆☆
Secondary heating	Room heaters, dual fuel (mineral and wood)	—
Hot water	From main system	★★★★☆
Lighting	Low energy lighting in 40% of fixed outlets	★★★☆☆

Current primary energy use per square metre of floor area: 338 kWh/m² per year

The assessment does not take into consideration the physical condition of any element. 'Assumed' means that the insulation could not be inspected and an assumption has been made in the methodology based on age and type of construction.

See addendum on the last page relating to items in the table above.

Low and zero carbon energy sources

Low and zero carbon energy sources are sources of energy that release either very little or no carbon dioxide into the atmosphere when they are used. Installing these sources may help reduce energy bills as well as cutting carbon. There are none provided for this home.

Your home's heat demand

For most homes, the vast majority of energy costs derive from heating the home. Where applicable, this table shows the energy that could be saved in this property by insulating the loft and walls, based on typical energy use (shown within brackets as it is a reduction in energy use).

Heat demand	Existing dwelling	Impact of loft insulation	Impact of cavity wall insulation	Impact of solid wall insulation
Space heating (kWh per year)	18,668	N/A	(1,012)	(3,161)
Water heating (kWh per year)	2,217			

You could receive Renewable Heat Incentive (RHI) payments and help reduce carbon emissions by replacing your existing heating system with one that generates renewable heat, subject to meeting minimum energy efficiency requirements. The estimated energy required for space and water heating will form the basis of the payments. For more information, search for the domestic RHI on the www.gov.uk website.

Recommendations

The measures below will improve the energy performance of your dwelling. The performance ratings after improvements listed below are cumulative; that is, they assume the improvements have been installed in the order that they appear in the table. Further information about the recommended measures and other simple actions you could take today to save money is available at www.gov.uk/energy-grants-calculator. Before installing measures, you should make sure you have secured the appropriate permissions, where necessary. Such permissions might include permission from your landlord (if you are a tenant) or approval under Building Regulations for certain types of work.

Recommended measures	Indicative cost	Typical savings per year	Rating after improvement
Flat roof or sloping ceiling insulation	£850 - £1,500	£ 181	D60
Cavity wall insulation	£500 - £1,500	£ 55	D62
Internal or external wall insulation	£4,000 - £14,000	£ 173	C69
Floor insulation (solid floor)	£4,000 - £6,000	£ 33	C70
Low energy lighting for all fixed outlets	£45	£ 33	C71
Heating controls (thermostatic radiator valves)	£350 - £450	£ 28	C72
Solar water heating	£4,000 - £6,000	£ 33	C73
Replacement glazing units	£1,000 - £1,400	£ 52	C75
Solar photovoltaic panels, 2.5 kWp	£5,000 - £8,000	£ 271	B85

Alternative measures

There are alternative measures below which you could also consider for your home.

- External insulation with cavity wall insulation

Opportunity to benefit from a Green Deal on this property

Green Deal Finance allows you to pay for some of the cost of your improvements in instalments under a Green Deal Plan (note that this is a credit agreement, but with instalments being added to the electricity bill for the property). The availability of a Green Deal Plan will depend upon your financial circumstances. There is a limit to how much Green Deal Finance can be used, which is determined by how much energy the improvements are estimated to **save** for a 'typical household'.

You may be able to obtain support towards repairs or replacements of heating systems and/or basic insulation measures, if you are in receipt of qualifying benefits or tax credits. To learn more about this scheme and the rules about eligibility, call the Energy Saving Advice Service on **0300 123 1234** for England and Wales.

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This document has been produced following an energy assessment undertaken by a qualified Energy Assessor, accredited by Elmhurst Energy Systems Ltd. You can obtain contact details of the Accreditation Scheme at www.elmhurstenergy.co.uk.

A copy of this certificate has been lodged on a national register as a requirement under the Energy Performance of Buildings Regulations 2012 as amended. It will be made available via the online search function at www.epcregister.com. The certificate (including the building address) and other data about the building collected during the energy assessment but not shown on the certificate, for instance heating system data, will be made publicly available at www.opendatacommunities.org.

This certificate and other data about the building may be shared with other bodies (including government departments and enforcement agencies) for research, statistical and enforcement purposes. For further information about how data about the property are used, please visit www.epcregister.com. To opt out of having information about your building made publicly available, please visit www.epcregister.com/optout.

Assessor's accreditation number:	EES/006272
Assessor's name:	Mr. Toby Gledhill
Phone number:	01924 249970
E-mail address:	toby@w-y-p.co.uk
Related party disclosure:	No related party

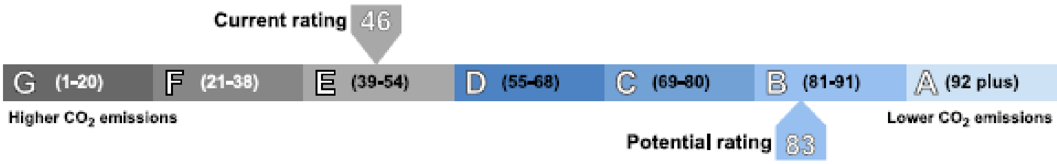
There is more information in the guidance document *Energy Performance Certificates for the marketing, sale and let of dwellings* available on the Government website at: www.gov.uk/government/collections/energy-performance-certificates. It explains the content and use of this document, advises on how to identify the authenticity of a certificate and how to make a complaint.

About the impact of buildings on the environment

One of the biggest contributors to global warming is carbon dioxide. The energy we use for heating, lighting and power in homes produces over a quarter of the UK's carbon dioxide emissions.

The average household causes about 6 tonnes of carbon dioxide every year. Based on this assessment, your home currently produces approximately 5.7 tonnes of carbon dioxide every year. Adopting the recommendations in this report can reduce emissions and protect the environment. If you were to install these recommendations you could reduce this amount by 3.9 tonnes per year. You could reduce emissions even more by switching to renewable energy sources.

The environmental impact rating is a measure of a home's impact on the environment in terms of carbon dioxide (CO_2) emissions based on standardised assumptions about occupancy and energy use. The higher the rating the less impact it has on the environment.



Addendum

This dwelling has stone walls and so requires further investigation to establish whether these walls are of cavity construction and to determine which type of cavity wall insulation is best suited.

DEA 4, EPC Inputs, Test Property 1

RdSAP

elmhurst energy systems

Summary Information

Surveyor:	C300-0001				
Name:	Toby Gledhill		**Title:** Mr.	**Tel Number:**	
Survey Reference:	000226		**My Reference:**		
Current SAP rating:	E 54	**Potential SAP rating:** B 85		**Emissions (t/year):**	5.714 tonnes
Current EI rating:	E 46	**Potential EI rating:** B 83		**Fuel Bill:**	£1208

Property Details:

RdSAP version:	SAP 9.93
Reference Number:	C300-0001-000226
My Reference:	
Lodgement Required:	Yes
Regs Region:	England
EPC Language:	English
UPRN:	2561619768
Postcode:	WF4 3JN
Region:	East Pennines
House Name:	
House No:	7
Street:	Stoney Lane
Locality:	Chapelthorpe
Town:	WAKEFIELD
County:	West Yorkshire
Property Tenure:	Owner-occupied
Transaction Type:	Marketed Sale
Inspection Date:	17/01/2018
Process date:	23/01/2018

RdSAP Inputs

Property Description:

1.0 Property type:		H House
		E End-Terrace
2.0 Number of	**Storeys:**	2
	Habitable Rooms:	4
	Heated Habitable Rooms:	4
3.0 Date Built:	**Main Property**	A before 1900
	1st Extension	D 1950-1966
	2nd Extension	A before 1900

4.0 Dimensions:

Dimension type: Internal

	Floor Area [m2]	Room Height [m]	Heat Loss Wall Perimeter [m]	Party Wall Length [m]
Main Property				
1st Floor:	25.91	2.40	7.42	4.61
Lowest Floor:	25.91	2.24	12.03	4.61
1st Extension				
1st Floor:	12.61	2.27	10.42	0.00
Lowest Floor:	12.61	2.10	7.12	3.30
2nd Extension				
1st Floor:	0.00	0.00	0.00	0.00
Lowest Floor:	5.53	2.40	4.61	0.00

5.0 Conservatory:

Is there a conservatory?	Yes
Is it thermally separated?	No
Floor Area [m2]	10.92
Double Glazed	Yes
Glazed Perimeter [m]	2.95
Room Height	1 Storey

Summary Information

7.0 Walls:

Main Property

Type	SG Stone: granite or whinstone
Insulation	A As Built
Dry-lining	No
Wall Thickness Unknown	No
Wall Thickness [mm]	500
U-value Known	No
Party Wall Type	S Solid masonry / timber / system build

1st Extension

As Main Wall	No
Type	CA Cavity
Insulation	A As Built
Dry-lining	No
Wall Thickness Unknown	No
Wall Thickness [mm]	330
U-value Known	No
Party Wall Type	S Solid masonry / timber / system build

2nd Extension

As Main Wall	No
Type	SG Stone: granite or whinstone
Insulation	A As Built
Dry-lining	No
Wall Thickness Unknown	No
Wall Thickness [mm]	500
U-value Known	No

8.0 Roofs:

Main Property

Type	PS Pitched, sloping ceiling
Insulation Thickness	As Built
U-value Known	No

1st Extension

As Main	No
Type	F Flat
Insulation Thickness	As Built
U-value Known	No

2nd Extension

As Main	No
Type	PS Pitched, sloping ceiling
Insulation Thickness	As Built
U-value Known	No

9.0 Floors:

Main Property

Location	G Ground floor
Type	S Solid
Insulation	A As built
U-value Known	No

1st Extension

As Main	Yes
Location	G Ground floor
Type	S Solid
Insulation	A As built
U-value Known	No

2nd Extension

As Main	No
Location	E To external air
Type	T Suspended timber
Insulation	A As built
U-value Known	No

Summary Information

10.0 Doors:

Total Number of Doors	2
Number of Insulated Doors	0

11.0 Windows:

Glazed Area	T Typical
Proportion Double\Triple-glazed	100 %
Glazing	Double pre 2002
Frame Type	PVC frame
Glazing Gap	12 mm
Draught Proofing	100 %

12.0 Ventilation & Cooling

No. of open Fireplaces	0
Mechanical Ventilation	No
Fixed Space Cooling	No

13.0 Lighting

Total number of light fittings	15
Total number of L.E.L. fittings	6

14.0 Main Heating1

PCDF boiler Reference	10328 Vaillant, Ecotec Pro, 88.80%
Main Heating Code	BGW Post 98 Combi condens. with auto ign.
Heat Emitter	Radiators
Heat pump age	Unknown
Fuel Type	Mains gas
Flue Type	Balanced
Fan Assisted Flue	Yes
Design flow temperature	Unknown
PCDF Heating Controls	0
Main Heating Controls	CBC Programmer and room thermostat
PCDF Compensator	0
Percentage of Heat	100 %

14.1 Main Heating2

PCDF boiler Reference	0
Main Heating Code	
Percentage of Heat	0 %

Secondary Heating Code	RDM Closed room heater

15.0 Water Heating

Water Heating Code	HWP From the primary heating system

15.1 Hot Water Cylinder

Hot Water Cylinder Present	No

16.0 Solar water heating

Solar Water Heating	No

17.0 Waste Water Heat Recovery System

Total Number of rooms with bath and/or shower	1
Number of rooms with mixer shower and no bath	0
Number of rooms with bath and mixer shower	1
Is WWHRS present in the property?	No / Unknown

18.0 Flue Gas Heat Recovery System

Present	No

19.0 Photovoltaic Panel

Photovoltaic Panel	None

20.0 Wind Turbine

Terrain Type	Suburban
Wind turbine present?	No

21.0 Other Details

Electricity meter type	Single
Main gas	Yes

RdSAP elmhurst energy

elmhurst energy systems

Summary Information

Recommendations

- Loft insulation (Not applicable)
- Flat roof insulation (Recommended)
- Room-in-roof insulation (Not applicable)
- Cavity wall insulation (Recommended)
- Party wall insulation (Not applicable)
- Solid wall insulation (Recommended)
- Floor insulation (solid floor) (Recommended)
- Hot water cylinder insulation (Not applicable)
- Draught proofing (Already installed)
- Low energy lighting (Recommended)
- Cylinder thermostat (Not applicable)
- Heating controls for wet central heating system (Recommended)
- Upgrade boiler, same fuel (Already installed)
- Change heating to condensing gas condensing boiler (fuel switch) (Not applicable)
- Flue gas heat recovery in conjunction with new boiler (Not applicable)
- Solar water heating (Recommended)
- Heat recovery system for mixer showers (SAP increase too small)
- Replacement glazing units (Recommended)
- Insulated doors (SAP increase too small)
- Solar photovoltaic panels (Recommended)
- Wind turbine (Not applicable)

Alternative Recommendations

- External wall insulation with cavity insulation (Alternative measure)
- Biomass boiler (alternative) (Not applicable)
- Air or ground source heat pump (alternative) (Not applicable)
- Air or ground source heat pump with underfloor heating (alternative) (Not applicable)
- Micro CHP (alternative) (Not applicable)

Related Party Disclosure

No related party

Addenda

— **Any Wall Insulation Issues** —

, Cavity wall insulation recommended (Ext1)Stone walls are present (, MainExt2)

Has the property any 'Access Issues' for potential wall insulation?	No
Has the property any 'narrow cavity(s)' (<50mm)?	No
Is the property in a 'high exposure' location?	No

DEA 5, EPC, Test Property 1

Energy Performance Certificate

HM Government

7, Stoney Lane, Chapelthorpe, WAKEFIELD, WF4 3JN

Dwelling type:	End-terrace house	**Reference number:**	8828-6122-7160-5928-6906
Date of assessment:	08 February 2018	**Type of assessment:**	RdSAP, existing dwelling
Date of certificate:	15 February 2018	**Total floor area:**	97 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

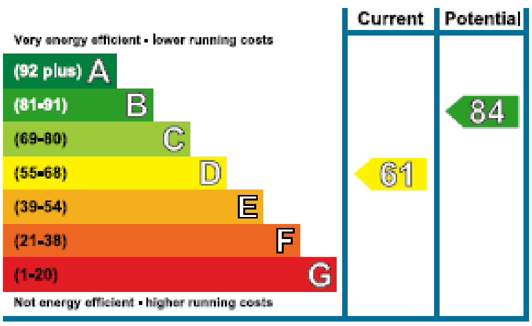
Estimated energy costs of dwelling for 3 years:	**£ 3,156**
Over 3 years you could save	**£ 1,107**

Estimated energy costs of this home

	Current costs	Potential costs	Potential future savings
Lighting	£ 192 over 3 years	£ 192 over 3 years	**You could save £ 1,107 over 3 years**
Heating	£ 2,697 over 3 years	£ 1,680 over 3 years	
Hot Water	£ 267 over 3 years	£ 177 over 3 years	
Totals	**£ 3,156**	**£ 2,049**	

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.

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

Recommended measures	Indicative cost	Typical savings over 3 years
1 Flat roof or sloping ceiling insulation	£850 - £1,500	£ 603
2 Cavity wall insulation	£500 - £1,500	£ 93
3 Internal or external wall insulation	£4,000 - £14,000	£ 321

See page 3 for a full list of recommendations for this property.

To find out more about the recommended measures and other actions you could take today to save money, visit www.gov.uk/energy-grants-calculator or call **0300 123 1234** (standard national rate). The Green Deal may enable you to make your home warmer and cheaper to run.

Summary of this home's energy performance related features

Element	Description	Energy Efficiency
Walls	Sandstone or limestone, as built, no insulation (assumed)	★☆☆☆☆
	Cavity wall, as built, no insulation (assumed)	★★☆☆☆
Roof	Pitched, no insulation (assumed)	★☆☆☆☆
	Flat, no insulation (assumed)	★☆☆☆☆
Floor	Solid, no insulation (assumed)	—
Windows	Fully double glazed	★★★☆☆
Main heating	Boiler and radiators, mains gas	★★★★☆
Main heating controls	Programmer, room thermostat and TRVs	★★★★☆
Secondary heating	Room heaters, wood logs	—
Hot water	From main system	★★★★☆
Lighting	Low energy lighting in all fixed outlets	★★★★★

Current primary energy use per square metre of floor area: 277 kWh/m² per year

The assessment does not take into consideration the physical condition of any element. 'Assumed' means that the insulation could not be inspected and an assumption has been made in the methodology based on age and type of construction.

See addendum on the last page relating to items in the table above.

Low and zero carbon energy sources

Low and zero carbon energy sources are sources of energy that release either very little or no carbon dioxide into the atmosphere when they are used. Installing these sources may help reduce energy bills as well as cutting carbon. The following low or zero carbon energy sources are provided for this home:

- Biomass secondary heating
- Wind turbine

Your home's heat demand

For most homes, the vast majority of energy costs derive from heating the home. Where applicable, this table shows the energy that could be saved in this property by insulating the loft and walls, based on typical energy use (shown within brackets as it is a reduction in energy use).

Heat demand	Existing dwelling	Impact of loft insulation	Impact of cavity wall insulation	Impact of solid wall insulation
Space heating (kWh per year)	16,453	N/A	(619)	(2,082)
Water heating (kWh per year)	1,969			

You could receive Renewable Heat Incentive (RHI) payments and help reduce carbon emissions by replacing your existing heating system with one that generates renewable heat, subject to meeting minimum energy efficiency requirements. The estimated energy required for space and water heating will form the basis of the payments. For more information, search for the domestic RHI on the www.gov.uk website.

Recommendations

The measures below will improve the energy performance of your dwelling. The performance ratings after improvements listed below are cumulative; that is, they assume the improvements have been installed in the order that they appear in the table. Further information about the recommended measures and other simple actions you could take today to save money is available at www.gov.uk/energy-grants-calculator. Before installing measures, you should make sure you have secured the appropriate permissions, where necessary. Such permissions might include permission from your landlord (if you are a tenant) or approval under Building Regulations for certain types of work.

Recommended measures	Indicative cost	Typical savings per year	Rating after improvement
Flat roof or sloping ceiling insulation	£850 - £1,500	£ 201	D68
Cavity wall insulation	£500 - £1,500	£ 31	C69
Internal or external wall insulation	£4,000 - £14,000	£ 107	C73
Solar water heating	£4,000 - £6,000	£ 30	C74
Solar photovoltaic panels, 2.5 kWp	£5,000 - £8,000	£ 271	B84

Alternative measures

There are alternative measures below which you could also consider for your home.

- External insulation with cavity wall insulation

Opportunity to benefit from a Green Deal on this property

Green Deal Finance allows you to pay for some of the cost of your improvements in instalments under a Green Deal Plan (note that this is a credit agreement, but with instalments being added to the electricity bill for the property). The availability of a Green Deal Plan will depend upon your financial circumstances. There is a limit to how much Green Deal Finance can be used, which is determined by how much energy the improvements are estimated to **save** for a 'typical household'.

You may be able to obtain support towards repairs or replacements of heating systems and/or basic insulation measures, if you are in receipt of qualifying benefits or tax credits. To learn more about this scheme and the rules about eligibility, call the Energy Saving Advice Service on **0300 123 1234** for England and Wales.

About this document and the data in it

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Assessor's accreditation number:	EES/006272
Assessor's name:	Mr. Toby Gledhill
Phone number:	01924 249970
E-mail address:	toby@w-y-p.co.uk
Related party disclosure:	No related party

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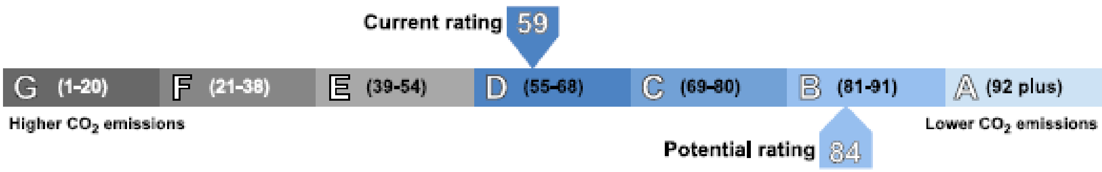
About the impact of buildings on the environment

One of the biggest contributors to global warming is carbon dioxide. The energy we use for heating, lighting and power in homes produces over a quarter of the UK's carbon dioxide emissions.

The average household causes about 6 tonnes of carbon dioxide every year. Based on this assessment, your home currently produces approximately 4.3 tonnes of carbon dioxide every year. Adopting the recommendations in this report can reduce emissions and protect the environment. If you were to install these recommendations you could reduce this amount by 2.6 tonnes per year. You could reduce emissions even more by switching to renewable energy sources.

The environmental impact rating is a measure of a home's impact on the environment in terms of carbon dioxide (CO_2) emissions based on standardised assumptions about occupancy and energy use. The higher the rating the less impact it has on the environment.



Addendum

This dwelling has stone walls and so requires further investigation to establish whether these walls are of cavity construction and to determine which type of cavity wall insulation is best suited. The property also requires further consideration of how to access the walls for installation of cavity wall insulation.

DEA 5, EPC Inputs, Test Property 1

RdSAP elmhurst energy

elmhurst energy systems

Summary Information

Surveyor:	C300-0001				
Name:	Toby Gledhill		Title: Mr.	Tel Number:	
Survey Reference:	000234		My Reference:		
Current SAP rating:	D 61	Potential SAP rating:	B 84	Emissions (t/year):	4.292 tonnes
Current EI rating:	D 59	Potential EI rating:	B 84	Fuel Bill:	£1029

Property Details:

RdSAP version:	SAP 9.93
Reference Number:	C300-0001-000234
My Reference:	
Lodgement Required:	Yes
Regs Region:	England
EPC Language:	English
UPRN:	2561619768
Postcode:	WF4 3JN
Region:	East Pennines
House Name:	
House No:	7
Street:	Stoney Lane
Locality:	Chapelthorpe
Town:	WAKEFIELD
County:	West Yorkshire
Property Tenure:	Owner-occupied
Transaction Type:	None of the above
Inspection Date:	08/02/2018
Process date:	15/02/2018

RdSAP Inputs

Property Description:

1.0 Property type:		H House E End-Terrace
2.0 Number of	Storeys:	2
	Habitable Rooms:	5
	Heated Habitable Rooms:	5
3.0 Date Built	Main Property	A before 1900
	1st Extension	D 1950-1966

4.0 Dimensions:

Dimension type: Internal

Main Property

	Floor Area [m2]	Room Height [m]	Heat Loss Wall Perimeter [m]	Party Wall Length [m]
1st Floor:	31.85	1.95	11.97	4.69
Lowest Floor:	25.76	2.20	11.97	4.69
1st Extension				
1st Floor:	14.09	2.29	7.61	3.67
Lowest Floor:	14.09	2.14	3.67	3.67

5.0 Conservatory:

Is there a conservatory?	Yes
Is it thermally separated?	No
Floor Area [m2]	11.05
Double Glazed	Yes
Glazed Perimeter [m]	3.12
Room Height	1 Storey

7.0 Walls:

Main Property

Type	SS Stone: sandstone or limestone
Insulation	A As Built
Dry-lining	No
Wall Thickness Unknown	No
Wall Thickness [mm]	570
U-value Known	No
Party Wall Type	S Solid masonry / timber / system build

RdSAP

elmhurst energy systems

Summary Information

14.1 Main Heating2

PCDF boiler Reference	0
Main Heating Code	
Percentage of Heat	0 %
Secondary Heating Code	RWM Closed room heater

15.0 Water Heating

Water Heating Code	HWP From the primary heating system

15.1 Hot Water Cylinder

Hot Water Cylinder Present	No

16.0 Solar water heating

Solar Water Heating	No

17.0 Waste Water Heat Recovery System

Total Number of rooms with bath and/or shower	1
Number of rooms with mixer shower and no bath	0
Number of rooms with bath and mixer shower	1
Is WWHRS present in the property?	No / Unknown

18.0 Flue Gas Heat Recovery System

Present	No

19.0 Photovoltaic Panel

Photovoltaic Panel	None

20.0 Wind Turbine

Terrain Type	Suburban
Wind turbine present?	Yes
Wind turbine details known?	No

21.0 Other Details

Electricity meter type	Single
Main gas	Yes

RdSAP elmhurst energy systems

Summary Information

1st Extension

As Main Wall	No
Type	CA Cavity
Insulation	A As Built
Dry-lining	No
Wall Thickness Unknown	No
Wall Thickness [mm]	300
U-value Known	No
Party Wall Type	CF Cavity masonry filled

8.0 Roofs:

Main Property

Type	PS Pitched, sloping ceiling
Insulation Thickness	As Built
U-value Known	No

1st Extension

As Main	No
Type	F Flat
Insulation Thickness	As Built
U-value Known	No

9.0 Floors:

Main Property

Location	G Ground floor
Type	S Solid
Insulation	A As built
U-value Known	No

1st Extension

As Main	No
Location	G Ground floor
Type	S Solid
Insulation	A As built
U-value Known	No

10.0 Doors:

Total Number of Doors	2
Number of Insulated Doors	0

11.0 Windows:

Glazed Area	M More than typical
Proportion Double\Triple-glazed	100 %
Glazing	Double pre 2002
Frame Type	Non-PVC frame
Draught Proofing	100 %

12.0 Ventilation & Cooling

No. of open Fireplaces	0
Mechanical Ventilation	No
Fixed Space Cooling	No

13.0 Lighting

Total number of light fittings	18
Total number of L.E.L. fittings	18

14.0 Main Heating1

PCDF boiler Reference	16839 Vaillant, ecoTEC pro 28, 89.30%
Main Heating Code	BGW Post 98 Combi condens. with auto ign.
Heat Emitter	Radiators
Heat pump age	Unknown
Fuel Type	Mains gas
Flue Type	Balanced
Fan Assisted Flue	Yes
Design flow temperature	Unknown
PCDF Heating Controls	0
Main Heating Controls	CBE Programmer, room thermostat and TRVs
PCDF Compensator	0
Percentage of Heat	100 %

RdSAP

elmhurst energy systems

Summary Information

14.1 Main Heating2

PCDF boiler Reference	0
Main Heating Code	
Percentage of Heat	0 %
Secondary Heating Code	RWM Closed room heater

15.0 Water Heating

Water Heating Code	HWP From the primary heating system

15.1 Hot Water Cylinder

Hot Water Cylinder Present	No

16.0 Solar water heating

Solar Water Heating	No

17.0 Waste Water Heat Recovery System

Total Number of rooms with bath and/or shower	1
Number of rooms with mixer shower and no bath	0
Number of rooms with bath and mixer shower	1
Is WWHRS present in the property?	No / Unknown

18.0 Flue Gas Heat Recovery System

Present	No

19.0 Photovoltaic Panel

Photovoltaic Panel	None

20.0 Wind Turbine

Terrain Type	Suburban
Wind turbine present?	Yes
Wind turbine details known?	No

21.0 Other Details

Electricity meter type	Single
Main gas	Yes

RdSAP

elmhurst energy systems

Summary Information

Recommendations

- Loft insulation (Not applicable)
- Flat roof insulation (Recommended)
- Room-in-roof insulation (Not applicable)
- Cavity wall insulation (Recommended)
- Party wall insulation (Already installed)
- Solid wall insulation (Recommended)
- Floor insulation (solid floor) (SAP increase too small)
- Hot water cylinder insulation (Not applicable)
- Draught proofing (Already installed)
- Low energy lighting (Already installed)
- Cylinder thermostat (Not applicable)
- Heating controls for wet central heating system (Already installed)
- Upgrade boiler, same fuel (Already installed)
- Change heating to condensing gas condensing boiler (fuel switch) (Not applicable)
- Flue gas heat recovery in conjunction with new boiler (Not applicable)
- Solar water heating (Recommended)
- Heat recovery system for mixer showers (SAP increase too small)
- Double glazed windows (Already installed)
- Insulated doors (SAP increase too small)
- Solar photovoltaic panels (Recommended)
- Wind turbine (Not applicable)

Alternative Recommendations

- External wall insulation with cavity insulation (Alternative measure)
- Biomass boiler (alternative) (Not applicable)
- Air or ground source heat pump (alternative) (Not applicable)
- Air or ground source heat pump with underfloor heating (alternative) (Not applicable)
- Micro CHP (alternative) (Not applicable)

Related Party Disclosure

No related party

Addenda

— Any Wall Insulation Issues —

, Cavity wall insulation recommended (Ext1)Stone walls are present (Main)

Has the property any 'Access Issues' for potential wall insulation?	Yes
Has the property any 'narrow cavity(s)' (<50mm)?	No
Is the property in a 'high exposure' location?	No

DEA 6, EPC, Test Property 1

Energy Performance Certificate

HM Government

7, Stoney Lane, Chapelthorpe, WAKEFIELD, WF4 3JN

Dwelling type:	End-terrace house	**Reference number:**	8528-6127-7160-5909-6922
Date of assessment:	21 March 2018	**Type of assessment:**	RdSAP, existing dwelling
Date of certificate:	05 April 2018	**Total floor area:**	96 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

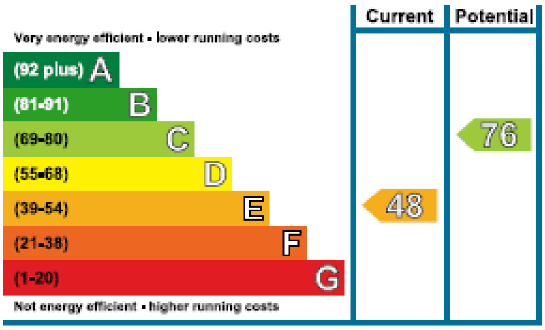
Estimated energy costs of dwelling for 3 years:	**£ 4,122**
Over 3 years you could save	**£ 1,470**

Estimated energy costs of this home

	Current costs	Potential costs	Potential future savings
Lighting	£ 297 over 3 years	£ 189 over 3 years	You could save £ 1,470 over 3 years
Heating	£ 2,973 over 3 years	£ 2,199 over 3 years	
Hot Water	£ 852 over 3 years	£ 264 over 3 years	
Totals	**£ 4,122**	**£ 2,652**	

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.

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

Recommended measures	Indicative cost	Typical savings over 3 years
1 Internal or external wall insulation	£4,000 - £14,000	£ 813
2 Low energy lighting for all fixed outlets	£50	£ 93
3 Solar water heating	£4,000 - £6,000	£ 558

See page 3 for a full list of recommendations for this property.

To find out more about the recommended measures and other actions you could take today to save money, visit www.gov.uk/energy-grants-calculator or call **0300 123 1234** (standard national rate). The Green Deal may enable you to make your home warmer and cheaper to run.

Summary of this home's energy performance related features

Element	Description	Energy Efficiency
Walls	Sandstone or limestone, as built, no insulation (assumed)	★☆☆☆☆
Roof	Pitched, no insulation (assumed)	★☆☆☆☆
	Flat, no insulation (assumed)	★☆☆☆☆
Floor	Solid, no insulation (assumed)	—
Windows	Fully double glazed	★★★★☆
Main heating	Boiler and radiators, mains gas	★★★★☆
Main heating controls	Programmer, room thermostat and TRVs	★★★★☆
Secondary heating	Room heaters, wood logs	—
Hot water	From main system, no cylinder thermostat	★★★☆☆
Lighting	Low energy lighting in 44% of fixed outlets	★★★☆☆

Current primary energy use per square metre of floor area: 381 kWh/m² per year

The assessment does not take into consideration the physical condition of any element. 'Assumed' means that the insulation could not be inspected and an assumption has been made in the methodology based on age and type of construction.

See addendum on the last page relating to items in the table above.

Low and zero carbon energy sources

Low and zero carbon energy sources are sources of energy that release either very little or no carbon dioxide into the atmosphere when they are used. Installing these sources may help reduce energy bills as well as cutting carbon. The following low or zero carbon energy sources are provided for this home:

- Biomass secondary heating

Your home's heat demand

For most homes, the vast majority of energy costs derive from heating the home. Where applicable, this table shows the energy that could be saved in this property by insulating the loft and walls, based on typical energy use (shown within brackets as it is a reduction in energy use).

Heat demand	Existing dwelling	Impact of loft insulation	Impact of cavity wall insulation	Impact of solid wall insulation
Space heating (kWh per year)	16,416	(2,670)	N/A	(5,289)
Water heating (kWh per year)	5,255			

You could receive Renewable Heat Incentive (RHI) payments and help reduce carbon emissions by replacing your existing heating system with one that generates renewable heat, subject to meeting minimum energy efficiency requirements. The estimated energy required for space and water heating will form the basis of the payments. For more information, search for the domestic RHI on the www.gov.uk website.

Recommendations

The measures below will improve the energy performance of your dwelling. The performance ratings after improvements listed below are cumulative; that is, they assume the improvements have been installed in the order that they appear in the table. Further information about the recommended measures and other simple actions you could take today to save money is available at www.gov.uk/energy-grants-calculator. Before installing measures, you should make sure you have secured the appropriate permissions, where necessary. Such permissions might include permission from your landlord (if you are a tenant) or approval under Building Regulations for certain types of work.

Recommended measures	Indicative cost	Typical savings per year	Rating after improvement
Internal or external wall insulation	£4,000 - £14,000	£ 271	D58
Low energy lighting for all fixed outlets	£50	£ 31	D59
Solar water heating	£4,000 - £6,000	£ 186	D66
Solar photovoltaic panels, 2.5 kWp	£5,000 - £8,000	£ 271	C76

Opportunity to benefit from a Green Deal on this property

Green Deal Finance allows you to pay for some of the cost of your improvements in instalments under a Green Deal Plan (note that this is a credit agreement, but with instalments being added to the electricity bill for the property). The availability of a Green Deal Plan will depend upon your financial circumstances. There is a limit to how much Green Deal Finance can be used, which is determined by how much energy the improvements are estimated to **save** for a 'typical household'.

You may be able to obtain support towards repairs or replacements of heating systems and/or basic insulation measures, if you are in receipt of qualifying benefits or tax credits. To learn more about this scheme and the rules about eligibility, call the Energy Saving Advice Service on **0300 123 1234** for England and Wales.

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This certificate and other data about the building may be shared with other bodies (including government departments and enforcement agencies) for research, statistical and enforcement purposes. For further information about how data about the property are used, please visit www.epcregister.com. To opt out of having information about your building made publicly available, please visit www.epcregister.com/optout.

Assessor's accreditation number:	EES/006272
Assessor's name:	Mr. Toby Gledhill
Phone number:	01924 249970
E-mail address:	toby@w-y-p.co.uk
Related party disclosure:	No related party

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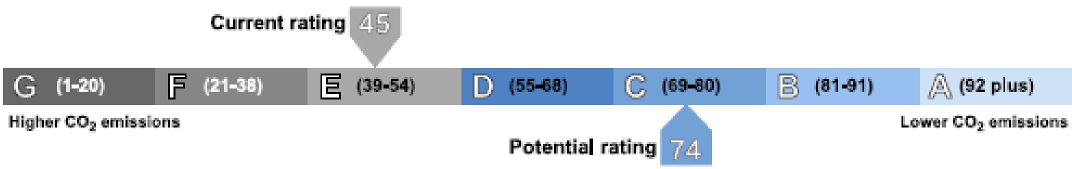
About the impact of buildings on the environment

One of the biggest contributors to global warming is carbon dioxide. The energy we use for heating, lighting and power in homes produces over a quarter of the UK's carbon dioxide emissions.

The average household causes about 6 tonnes of carbon dioxide every year. Based on this assessment, your home currently produces approximately 6.0 tonnes of carbon dioxide every year. Adopting the recommendations in this report can reduce emissions and protect the environment. If you were to install these recommendations you could reduce this amount by 3.3 tonnes per year. You could reduce emissions even more by switching to renewable energy sources.

The environmental impact rating is a measure of a home's impact on the environment in terms of carbon dioxide (CO_2) emissions based on standardised assumptions about occupancy and energy use. The higher the rating the less impact it has on the environment.



Addendum

This dwelling has stone walls and so requires further investigation to establish whether these walls are of cavity construction and to determine which type of cavity wall insulation is best suited.

DEA 6, EPC Inputs, Test Property 1

RdSAP elmhurst energy systems

Summary Information

Surveyor:	C300-0001				
Name:	Toby Gledhill	**Title:** Mr.		**Tel Number:**	
Survey Reference:	000249	**My Reference:**			
Current SAP rating:	E 48	**Potential SAP rating:**	C 76	**Emissions (t/year):**	6.023 tonnes
Current EI rating:	E 45	**Potential EI rating:**	C 74	**Fuel Bill:**	£1373

Property Details:

RdSAP version:	SAP 9.93
Reference Number:	C300-0001-000249
My Reference:	
Lodgement Required:	Yes
Regs Region:	England
EPC Language:	English
UPRN:	2561619768
Postcode:	WF4 3JN
Region:	East Pennines
House Name:	
House No:	7
Street:	Stoney Lane
Locality:	Chapelthorpe
Town:	WAKEFIELD
County:	West Yorkshire
Property Tenure:	Owner-occupied
Transaction Type:	None of the above
Inspection Date:	21/03/2018
Process date:	05/04/2018

RdSAP Inputs

Property Description:

1.0 Property type:		H House E End-Terrace
2.0 Number of	**Storeys:**	2
	Habitable Rooms:	5
	Heated Habitable Rooms:	4
3.0 Date Built	**Main Property**	A before 1900
	1st Extension	D 1950-1966

4.0 Dimensions:

Dimension type: **Internal**

Main Property	Floor Area [m2]	Room Height [m]	Heat Loss Wall Perimeter [m]	Party Wall Length [m]
1st Floor:	32.16	1.95	14.46	4.73
Lowest Floor:	25.83	2.06	11.99	4.62
1st Extension				
1st Floor:	13.91	2.28	11.11	0.00
Lowest Floor:	13.91	2.14	3.76	3.65

5.0 Conservatory:

Is there a conservatory?	Yes
Is it thermally separated?	No
Floor Area [m2]	10.35
Double Glazed	Yes
Glazed Perimeter [m]	3.36
Room Height	1 Storey

7.0 Walls:

Main Property

Type	SS Stone: sandstone or limestone
Insulation	A As Built
Dry-lining	No
Wall Thickness Unknown	No
Wall Thickness [mm]	500
U-value Known	No
Party Wall Type	U Unable to determine

RdSAP elmhurst energy systems

Summary Information

1st Extension

As Main Wall	No
Type	SS Stone: sandstone or limestone
Insulation	A As Built
Dry-lining	No
Wall Thickness Unknown	No
Wall Thickness [mm]	360
U-value Known	No
Party Wall Type	U Unable to determine

8.0 Roofs:

Main Property

Type	PN Pitched (slates/tiles), no access
Insulation	U Unknown
U-value Known	No

1st Extension

As Main	No
Type	F Flat
Insulation Thickness	Unknown
U-value Known	No

9.0 Floors:

Main Property

Location	G Ground floor
Type	S Solid
Insulation	A As built
U-value Known	No

1st Extension

As Main	Yes
Location	G Ground floor
Type	S Solid
Insulation	A As built
U-value Known	No

10.0 Doors:

Total Number of Doors	2
Number of Insulated Doors	0

11.0 Windows:

Glazed Area	T Typical
Proportion Double\Triple-glazed	100 %
Glazing	Double post or during 2002
Draught Proofing	100 %

12.0 Ventilation & Cooling

No. of open Fireplaces	0
Mechanical Ventilation	No
Fixed Space Cooling	No

13.0 Lighting

Total number of light fittings	18
Total number of L.E.L. fittings	8

14.0 Main Heating1

PCDF boiler Reference	0
Main Heating Code	BGB Post 98 Regular condens. with auto ign.
Heat Emitter	Radiators
Heat pump age	Unknown
Flue Type	Balanced
Fan Assisted Flue	Yes
Design flow temperature	Normal (> 45°C)
PCDF Heating Controls	0
Main Heating Controls	CBE Programmer, room thermostat and TRVs
PCDF Compensator	0
Percentage of Heat	100 %

RdSAP elmhurst energy

elmhurst energy systems

Summary Information

14.1 Main Heating2

PCDF boiler Reference	0
Main Heating Code	
Percentage of Heat	0 %
Secondary Heating Code	RWM Closed room heater

15.0 Water Heating

Water Heating Code	HWP From the primary heating system

15.1 Hot Water Cylinder

Hot Water Cylinder Present	Yes
Cylinder Size	No Access

16.0 Solar water heating

Solar Water Heating	No

17.0 Waste Water Heat Recovery System

Total Number of rooms with bath and/or shower	1
Number of rooms with mixer shower and no bath	0
Number of rooms with bath and mixer shower	1
Is WWHRS present in the property?	No / Unknown

18.0 Flue Gas Heat Recovery System

Present	No

19.0 Photovoltaic Panel

Photovoltaic Panel	None

20.0 Wind Turbine

Terrain Type	Suburban
Wind turbine present?	No

21.0 Other Details

Electricity meter type	Single
Main gas	Yes

RdSAP

elmhurst energy systems

Summary Information

Recommendations

- Loft insulation (Not applicable)
- Flat roof insulation (Not applicable)
- Room-in-roof insulation (Not applicable)
- Cavity wall insulation (Not applicable)
- Party wall insulation (Not applicable)
- Solid wall insulation (Recommended)
- Floor insulation (solid floor) (SAP increase too small)
- Hot water cylinder insulation (Not applicable)
- Draught proofing (Already installed)
- Low energy lighting (Recommended)
- Cylinder thermostat (Not applicable)
- Heating controls for wet central heating system (Already installed)
- Upgrade boiler, same fuel (Already installed)
- Change heating to condensing gas condensing boiler (fuel switch) (Not applicable)
- Flue gas heat recovery in conjunction with new boiler (Not applicable)
- Solar water heating (Recommended)
- Heat recovery system for mixer showers (SAP increase too small)
- Double glazed windows (Already installed)
- Insulated doors (SAP increase too small)
- Solar photovoltaic panels (Recommended)
- Wind turbine (Not applicable)

Alternative Recommendations

- External wall insulation with cavity insulation (Not applicable)
- Biomass boiler (alternative) (Not applicable)
- Air or ground source heat pump (alternative) (Not applicable)
- Air or ground source heat pump with underfloor heating (alternative) (Not applicable)
- Micro CHP (alternative) (Not applicable)

Related Party Disclosure

No related party

Addenda

— Any Wall Insulation Issues —

Has the property any 'Access Issues' for potential wall insulation?	No
Is the property in a 'high exposure' location?	No

DEA 7, EPC, Test Property 1

Energy Performance Certificate

HM Government

7, Stoney Lane, Chapelthorpe, WAKEFIELD, WF4 3JN

Dwelling type:	End-terrace house	**Reference number:**	9168-2016-6264-7898-1950
Date of assessment:	16 April 2018	**Type of assessment:**	RdSAP, existing dwelling
Date of certificate:	16 April 2018	**Total floor area:**	77 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

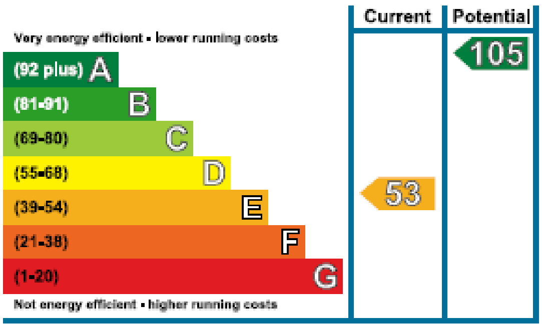
Estimated energy costs of dwelling for 3 years:	**£ 3,192**
Over 3 years you could save	**£ 1,293**

Estimated energy costs of this home

	Current costs	Potential costs	Potential future savings
Lighting	£ 279 over 3 years	£ 162 over 3 years	**You could save £ 1,293 over 3 years**
Heating	£ 2,616 over 3 years	£ 1,533 over 3 years	
Hot Water	£ 297 over 3 years	£ 204 over 3 years	
Totals	**£ 3,192**	**£ 1,899**	

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.

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

Recommended measures	Indicative cost	Typical savings over 3 years
1 Flat roof or sloping ceiling insulation	£850 - £1,500	£ 501
2 Internal or external wall insulation	£4,000 - £14,000	£ 591
3 Low energy lighting for all fixed outlets	£40	£ 105

See page 3 for a full list of recommendations for this property.

To find out more about the recommended measures and other actions you could take today to save money, visit www.gov.uk/energy-grants-calculator or call **0300 123 1234** (standard national rate). The Green Deal may enable you to make your home warmer and cheaper to run.

Summary of this home's energy performance related features

Element	Description	Energy Efficiency
Walls	Granite or whinstone, as built, no insulation (assumed)	★☆☆☆☆
Roof	Pitched, no insulation (assumed)	★☆☆☆☆
	Flat, limited insulation (assumed)	★☆☆☆☆
Floor	Solid, no insulation (assumed)	—
	To external air, no insulation (assumed)	—
Windows	Fully double glazed	★★★☆☆
Main heating	Boiler and radiators, mains gas	★★★★☆
Main heating controls	Programmer, room thermostat and TRVs	★★★★☆
Secondary heating	Room heaters, wood logs	—
Hot water	From main system	★★★★☆
Lighting	Low energy lighting in 27% of fixed outlets	★★★☆☆

Current primary energy use per square metre of floor area: 356 kWh/m² per year

The assessment does not take into consideration the physical condition of any element. 'Assumed' means that the insulation could not be inspected and an assumption has been made in the methodology based on age and type of construction.

See addendum on the last page relating to items in the table above.

Low and zero carbon energy sources

Low and zero carbon energy sources are sources of energy that release either very little or no carbon dioxide into the atmosphere when they are used. Installing these sources may help reduce energy bills as well as cutting carbon. The following low or zero carbon energy sources are provided for this home:

- Biomass secondary heating

Your home's heat demand

For most homes, the vast majority of energy costs derive from heating the home. Where applicable, this table shows the energy that could be saved in this property by insulating the loft and walls, based on typical energy use (shown within brackets as it is a reduction in energy use).

Heat demand	Existing dwelling	Impact of loft insulation	Impact of cavity wall insulation	Impact of solid wall insulation
Space heating (kWh per year)	15,806	N/A	(104)	(4,035)
Water heating (kWh per year)	2,112			

You could receive Renewable Heat Incentive (RHI) payments and help reduce carbon emissions by replacing your existing heating system with one that generates renewable heat, subject to meeting minimum energy efficiency requirements. The estimated energy required for space and water heating will form the basis of the payments. For more information, search for the domestic RHI on the www.gov.uk website.

Recommendations

The measures below will improve the energy performance of your dwelling. The performance ratings after improvements listed below are cumulative; that is, they assume the improvements have been installed in the order that they appear in the table. Further information about the recommended measures and other simple actions you could take today to save money is available at www.gov.uk/energy-grants-calculator. Before installing measures, you should make sure you have secured the appropriate permissions, where necessary. Such permissions might include permission from your landlord (if you are a tenant) or approval under Building Regulations for certain types of work.

Recommended measures	Indicative cost	Typical savings per year	Rating after improvement
Flat roof or sloping ceiling insulation	£850 - £1,500	£ 167	D60
Internal or external wall insulation	£4,000 - £14,000	£ 197	C69
Low energy lighting for all fixed outlets	£40	£ 35	C70
Solar water heating	£4,000 - £6,000	£ 31	C71
Solar photovoltaic panels, 2.5 kWp	£5,000 - £8,000	£ 271	B82
Wind turbine	£15,000 - £25,000	£ 576	A105

Opportunity to benefit from a Green Deal on this property

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Assessor's accreditation number:	EES/006272
Assessor's name:	Mr. Toby Gledhill
Phone number:	01924 249970
E-mail address:	toby@w-y-p.co.uk
Related party disclosure:	No related party

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The average household causes about 6 tonnes of carbon dioxide every year. Based on this assessment, your home currently produces approximately 4.4 tonnes of carbon dioxide every year. Adopting the recommendations in this report can reduce emissions and protect the environment. If you were to install these recommendations you could reduce this amount by 4.7 tonnes per year. You could reduce emissions even more by switching to renewable energy sources.

The environmental impact rating is a measure of a home's impact on the environment in terms of carbon dioxide (CO_2) emissions based on standardised assumptions about occupancy and energy use. The higher the rating the less impact it has on the environment.

Addendum

This dwelling has stone walls and so requires further investigation to establish whether these walls are of cavity construction and to determine which type of cavity wall insulation is best suited.

DEA 7, EPC Inputs, Test Property 1

RdSAP

elmhurst energy systems

Summary Information

Surveyor:	C300-0001				
Name:	Toby Gledhill	**Title:** Mr.		**Tel Number:**	
Survey Reference:	000255	**My Reference:**			
Current SAP rating:	E 53	**Potential SAP rating:**	A 105	**Emissions (t/year):**	4.394 tonnes
Current EI rating:	E 52	**Potential EI rating:**	A 103	**Fuel Bill:**	£1064

Property Details:

RdSAP version:	SAP 9.93
Reference Number:	C300-0001-000255
My Reference:	
Lodgement Required:	Yes
Regs Region:	England
EPC Language:	English
UPRN:	2561619768
Postcode:	WF4 3JN
Region:	East Pennines
House Name:	
House No:	7
Street:	Stoney Lane
Locality:	Chapelthorpe
Town:	WAKEFIELD
County:	West Yorkshire
Property Tenure:	Owner-occupied
Transaction Type:	None of the above
Inspection Date:	16/04/2018
Process date:	16/04/2018

RdSAP Inputs

Property Description:

1.0 Property type:		H House E End-Terrace
2.0 Number of	**Storeys:**	2
	Habitable Rooms:	4
	Heated Habitable Rooms:	4
3.0 Date Built	**Main Property**	A before 1900
	1st Extension	A before 1900
	2nd Extension	E 1967-1975

4.0 Dimensions:

Dimension type: Internal

Main Property	**Floor Area [m2]**	**Room Height [m]**	**Heat Loss Wall Perimeter [m]**	**Party Wall Length [m]**
1st Floor:	25.76	2.70	7.30	4.60
Lowest Floor:	25.76	2.30	11.90	4.60
1st Extension				
1st Floor:	0.00	0.00	0.00	0.00
Lowest Floor:	5.52	2.70	7.00	0.00
2nd Extension				
1st Floor:	0.00	0.00	0.00	0.00
Lowest Floor:	8.97	2.30	2.30	2.30

5.0 Conservatory:

Is there a conservatory?	Yes
Is it thermally separated?	No
Floor Area [m2]	11.00
Double Glazed	Yes
Glazed Perimeter [m]	2.90
Room Height	1 Storey

Summary Information

7.0 Walls:

Main Property

Type	SG Stone: granite or whinstone
Insulation	A As Built
Dry-lining	No
Wall Thickness Unknown	No
Wall Thickness [mm]	500
U-value Known	No
Party Wall Type	U Unable to determine

1st Extension

As Main Wall	No
Type	SG Stone: granite or whinstone
Insulation	A As Built
Dry-lining	No
Wall Thickness Unknown	No
Wall Thickness [mm]	500
U-value Known	No

2nd Extension

As Main Wall	No
Type	CA Cavity
Insulation	A As Built
Dry-lining	No
Wall Thickness Unknown	No
Wall Thickness [mm]	320
U-value Known	No
Party Wall Type	U Unable to determine

8.0 Roofs:

Main Property

Type	PS Pitched, sloping ceiling
Insulation Thickness	As Built
U-value Known	No

1st Extension

As Main	No
Type	PS Pitched, sloping ceiling
Insulation Thickness	As Built
U-value Known	No

2nd Extension

As Main	No
Type	F Flat
Insulation Thickness	As Built
U-value Known	No

9.0 Floors:

Main Property

Location	G Ground floor
Type	S Solid
Insulation	A As built
U-value Known	No

1st Extension

As Main	No
Location	E To external air
Type	T Suspended timber
Insulation	A As built
U-value Known	No

2nd Extension

As Main	No
Location	G Ground floor
Type	S Solid
Insulation	A As built
U-value Known	No

Summary Information

10.0 Doors:

Total Number of Doors	2
Number of Insulated Doors	0

11.0 Windows:

Glazed Area	T Typical
Proportion Double\Triple-glazed	100 %
Glazing	Double with unknown install date
Frame Type	Non-PVC frame
Draught Proofing	100 %

12.0 Ventilation & Cooling

No. of open Fireplaces	0
Mechanical Ventilation	No
Fixed Space Cooling	No

13.0 Lighting

Total number of light fittings	11
Total number of L.E.L. fittings	3

14.0 Main Heating1

PCDF boiler Reference	10328 Vaillant, Ecotec Pro, 88.80%
Main Heating Code	BGW Post 98 Combi condens. with auto ign.
Heat Emitter	Radiators
Heat pump age	Unknown
Fuel Type	Mains gas
Flue Type	Balanced
Fan Assisted Flue	Yes
Design flow temperature	Unknown
PCDF Heating Controls	0
Main Heating Controls	CBE Programmer, room thermostat and TRVs
PCDF Compensator	0
Percentage of Heat	100 %

14.1 Main Heating2

PCDF boiler Reference	0
Main Heating Code	
Percentage of Heat	0 %
Secondary Heating Code	RWM Closed room heater

15.0 Water Heating

Water Heating Code	HWP From the primary heating system

15.1 Hot Water Cylinder

Hot Water Cylinder Present	No

16.0 Solar water heating

Solar Water Heating	No

17.0 Waste Water Heat Recovery System

Total Number of rooms with bath and/or shower	1
Number of rooms with mixer shower and no bath	0
Number of rooms with bath and mixer shower	1
Is WWHRS present in the property?	No / Unknown

18.0 Flue Gas Heat Recovery System

Present	No

19.0 Photovoltaic Panel

Photovoltaic Panel	None

20.0 Wind Turbine

Terrain Type	Rural
Wind turbine present?	No

21.0 Other Details

Electricity meter type	Single
Main gas	Yes

RdSAP
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Summary Information

Recommendations

- Loft insulation (Not applicable)
- Flat roof insulation (Recommended)
- Room-in-roof insulation (Not applicable)
- Cavity wall insulation (SAP increase too small)
- Party wall insulation (Not applicable)
- Solid wall insulation (Recommended)
- Floor insulation (suspended floor) (SAP increase too small)
- Hot water cylinder insulation (Not applicable)
- Draught proofing (Already installed)
- Low energy lighting (Recommended)
- Cylinder thermostat (Not applicable)
- Heating controls for wet central heating system (Already installed)
- Upgrade boiler, same fuel (Already installed)
- Change heating to condensing gas condensing boiler (fuel switch) (Not applicable)
- Flue gas heat recovery in conjunction with new boiler (Not applicable)
- Solar water heating (Recommended)
- Heat recovery system for mixer showers (SAP increase too small)
- Double glazed windows (Already installed)
- Insulated doors (SAP increase too small)
- Solar photovoltaic panels (Recommended)
- Wind turbine (Recommended)

Alternative Recommendations

- External wall insulation with cavity insulation (Not applicable)
- Biomass boiler (alternative) (Not applicable)
- Air or ground source heat pump (alternative) (Not applicable)
- Air or ground source heat pump with underfloor heating (alternative) (Not applicable)
- Micro CHP (alternative) (Not applicable)

Related Party Disclosure

No related party

Addenda

--- Any Wall Insulation Issues ---

Has the property any 'Access Issues' for potential wall insulation?	No
Is the property in a 'high exposure' location?	No

DEA 8, EPC, Test Property 1

Energy Performance Certificate

HM Government

7, Stoney Lane, Chapelthorpe, WAKEFIELD, WF4 3JN

Dwelling type:	End-terrace house	**Reference number:**	8828-6127-7160-5919-6926
Date of assessment:	21 March 2018	**Type of assessment:**	RdSAP, existing dwelling
Date of certificate:	20 April 2018	**Total floor area:**	95 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

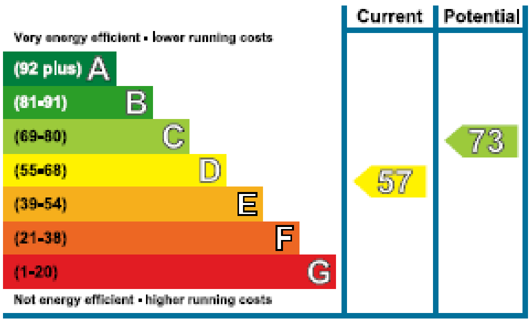
Estimated energy costs of dwelling for 3 years:	**£ 3,384**
Over 3 years you could save	**£ 531**

Estimated energy costs of this home

	Current costs	Potential costs	Potential future savings
Lighting	£ 351 over 3 years	£ 189 over 3 years	You could save £ 531 over 3 years
Heating	£ 2,721 over 3 years	£ 2,448 over 3 years	
Hot Water	£ 312 over 3 years	£ 216 over 3 years	
Totals	**£ 3,384**	**£ 2,853**	

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.

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

Recommended measures	Indicative cost	Typical savings over 3 years
1 Flat roof or sloping ceiling insulation	£850 - £1,500	£ 159
2 Cavity wall insulation	£500 - £1,500	£ 129
3 Low energy lighting for all fixed outlets	£65	£ 147

See page 3 for a full list of recommendations for this property.

To find out more about the recommended measures and other actions you could take today to save money, visit www.gov.uk/energy-grants-calculator or call **0300 123 1234** (standard national rate). The Green Deal may enable you to make your home warmer and cheaper to run.

Summary of this home's energy performance related features

Element	Description	Energy Efficiency
Walls	Sandstone or limestone, as built, no insulation (assumed)	★☆☆☆☆
	Cavity wall, as built, no insulation (assumed)	★★☆☆☆
Roof	Pitched, insulated at rafters	★☆☆☆☆
	Flat, no insulation (assumed)	★☆☆☆☆
Floor	Solid, no insulation (assumed)	—
Windows	Fully double glazed	★★★☆☆
Main heating	Boiler and radiators, mains gas	★★★★☆
Main heating controls	Programmer, room thermostat and TRVs	★★★★☆
Secondary heating	None	—
Hot water	From main system	★★★★☆
Lighting	Low energy lighting in 13% of fixed outlets	★★☆☆☆

Current primary energy use per square metre of floor area: 317 kWh/m² per year

The assessment does not take into consideration the physical condition of any element. 'Assumed' means that the insulation could not be inspected and an assumption has been made in the methodology based on age and type of construction.

See addendum on the last page relating to items in the table above.

Low and zero carbon energy sources

Low and zero carbon energy sources are sources of energy that release either very little or no carbon dioxide into the atmosphere when they are used. Installing these sources may help reduce energy bills as well as cutting carbon. There are none provided for this home.

Your home's heat demand

For most homes, the vast majority of energy costs derive from heating the home. Where applicable, this table shows the energy that could be saved in this property by insulating the loft and walls, based on typical energy use (shown within brackets as it is a reduction in energy use).

Heat demand	Existing dwelling	Impact of loft insulation	Impact of cavity wall insulation	Impact of solid wall insulation
Space heating (kWh per year)	17,740	N/A	(973)	(3,310)
Water heating (kWh per year)	2,223			

You could receive Renewable Heat Incentive (RHI) payments and help reduce carbon emissions by replacing your existing heating system with one that generates renewable heat, subject to meeting minimum energy efficiency requirements. The estimated energy required for space and water heating will form the basis of the payments. For more information, search for the domestic RHI on the www.gov.uk website.

Recommendations

The measures below will improve the energy performance of your dwelling. The performance ratings after improvements listed below are cumulative; that is, they assume the improvements have been installed in the order that they appear in the table. Further information about the recommended measures and other simple actions you could take today to save money is available at www.gov.uk/energy-grants-calculator. Before installing measures, you should make sure you have secured the appropriate permissions, where necessary. Such permissions might include permission from your landlord (if you are a tenant) or approval under Building Regulations for certain types of work.

Recommended measures	Indicative cost	Typical savings per year	Rating after improvement
Flat roof or sloping ceiling insulation	£850 - £1,500	£ 53	D59
Cavity wall insulation	£500 - £1,500	£ 43	D61
Low energy lighting for all fixed outlets	£65	£ 49	D62
Solar water heating	£4,000 - £6,000	£ 32	D64
Solar photovoltaic panels, 2.5 kWp	£5,000 - £8,000	£ 271	C73

Alternative measures

There are alternative measures below which you could also consider for your home.

- External insulation with cavity wall insulation

Opportunity to benefit from a Green Deal on this property

Green Deal Finance allows you to pay for some of the cost of your improvements in instalments under a Green Deal Plan (note that this is a credit agreement, but with instalments being added to the electricity bill for the property). The availability of a Green Deal Plan will depend upon your financial circumstances. There is a limit to how much Green Deal Finance can be used, which is determined by how much energy the improvements are estimated to **save** for a 'typical household'.

You may be able to obtain support towards repairs or replacements of heating systems and/or basic insulation measures, if you are in receipt of qualifying benefits or tax credits. To learn more about this scheme and the rules about eligibility, call the Energy Saving Advice Service on **0300 123 1234** for England and Wales.

About this document and the data in it

This document has been produced following an energy assessment undertaken by a qualified Energy Assessor, accredited by Elmhurst Energy Systems Ltd. You can obtain contact details of the Accreditation Scheme at www.elmhurstenergy.co.uk.

A copy of this certificate has been lodged on a national register as a requirement under the Energy Performance of Buildings Regulations 2012 as amended. It will be made available via the online search function at www.epcregister.com. The certificate (including the building address) and other data about the building collected during the energy assessment but not shown on the certificate, for instance heating system data, will be made publicly available at www.opendatacommunities.org.

This certificate and other data about the building may be shared with other bodies (including government departments and enforcement agencies) for research, statistical and enforcement purposes. Any personal data it contains will be processed in accordance with the General Data Protection Regulation and all applicable laws and regulations relating to the processing of personal data and privacy. For further information about this and how data about the property are used, please visit www.epcregister.com. To opt out of having information about your building made publicly available, please visit www.epcregister.com/optout.

Assessor's accreditation number:	EES/006272
Assessor's name:	Mr. Toby Gledhill
Phone number:	01924 249970
E-mail address:	toby@w-y-p.co.uk
Related party disclosure:	No related party

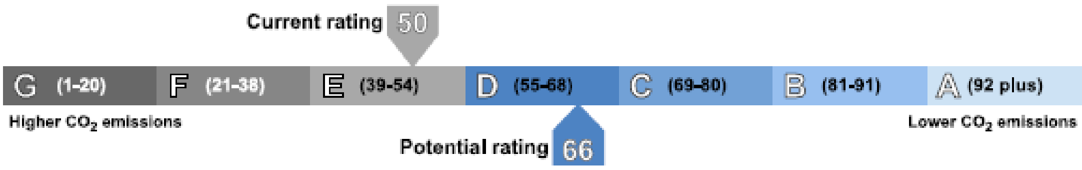
There is more information in the guidance document *Energy Performance Certificates for the marketing, sale and let of dwellings* available on the Government website at: www.gov.uk/government/collections/energy-performance-certificates. It explains the content and use of this document, advises on how to identify the authenticity of a certificate and how to make a complaint.

About the impact of buildings on the environment

One of the biggest contributors to global warming is carbon dioxide. The energy we use for heating, lighting and power in homes produces over a quarter of the UK's carbon dioxide emissions.

The average household causes about 6 tonnes of carbon dioxide every year. Based on this assessment, your home currently produces approximately 5.3 tonnes of carbon dioxide every year. Adopting the recommendations in this report can reduce emissions and protect the environment. If you were to install these recommendations you could reduce this amount by 1.7 tonnes per year. You could reduce emissions even more by switching to renewable energy sources.

The environmental impact rating is a measure of a home's impact on the environment in terms of carbon dioxide (CO_2) emissions based on standardised assumptions about occupancy and energy use. The higher the rating the less impact it has on the environment.



Addendum

This dwelling has stone walls and so requires further investigation to establish whether these walls are of cavity construction and to determine which type of cavity wall insulation is best suited.

DEA 8, EPC Inputs, Test Property 1

RdSAP

elmhurst energy systems

Summary Information

Surveyor:	C300-0001				
Name:	Toby Gledhill	Title: Mr.		Tel Number:	
Survey Reference:	000258	My Reference:			
Current SAP rating:	D 57	Potential SAP rating:	C 73	Emissions (t/year):	5.295 tonnes
Current EI rating:	E 50	Potential EI rating:	D 66	Fuel Bill:	£1128

Property Details:

RdSAP version:	SAP 9.93
Reference Number:	C300-0001-000258
My Reference:	
Lodgement Required:	Yes
Regs Region:	England
EPC Language:	English
UPRN:	2561619768
Postcode:	WF4 3JN
Region:	East Pennines
House Name:	
House No:	7
Street:	Stoney Lane
Locality:	Chapelthorpe
Town:	WAKEFIELD
County:	West Yorkshire
Property Tenure:	Owner-occupied
Transaction Type:	None of the above
Inspection Date:	21/03/2018
Process date:	20/04/2018

RdSAP Inputs

Property Description:

1.0 Property type:		H House E End-Terrace
2.0 Number of	Storeys:	2
	Habitable Rooms:	3
	Heated Habitable Rooms:	3
3.0 Date Built	Main Property	A before 1900
	1st Extension	D 1950-1966

4.0 Dimensions:

Dimension type: Internal

	Floor Area [m2]	Room Height [m]	Heat Loss Wall Perimeter [m]	Party Wall Length [m]
Main Property				
1st Floor:	28.95	2.52	12.42	5.62
Lowest Floor:	26.42	2.25	12.42	4.66
1st Extension				
1st Floor:	13.94	2.30	11.10	0.00
Lowest Floor:	13.94	2.10	3.73	3.63

5.0 Conservatory:

Is there a conservatory?	Yes
Is it thermally separated?	No
Floor Area [m2]	11.59
Double Glazed	Yes
Glazed Perimeter [m]	3.10
Room Height	1 Storey

7.0 Walls:

Main Property

Type	SS Stone: sandstone or limestone
Insulation	U Unknown
Dry-lining	No
Wall Thickness Unknown	No
Wall Thickness [mm]	480
U-value Known	No
Party Wall Type	U Unable to determine

Summary Information

1st Extension

As Main Wall	No
Type	CA Cavity
Insulation	A As Built
Dry-lining	No
Wall Thickness Unknown	No
Wall Thickness [mm]	360
U-value Known	No
Party Wall Type	U Unable to determine

8.0 Roofs:

Main Property

Type	PN Pitched (slates/tiles), no access
Insulation	R Rafters
Insulation Thickness	As Built
U-value Known	No

1st Extension

As Main	No
Type	F Flat
Insulation Thickness	As Built
U-value Known	No

9.0 Floors:

Main Property

Location	G Ground floor
Type	S Solid
Insulation	A As built
U-value Known	No

1st Extension

As Main	No
Location	G Ground floor
Type	U Unknown
Insulation	A As built
U-value Known	No

10.0 Doors:

Total Number of Doors	2
Number of Insulated Doors	0

11.0 Windows:

Glazed Area	T Typical
Proportion Double\Triple-glazed	100 %
Glazing	Double pre 2002
Frame Type	PVC frame
Glazing Gap	6 mm
Draught Proofing	100 %

12.0 Ventilation & Cooling

No. of open Fireplaces	0
Mechanical Ventilation	No
Fixed Space Cooling	No

13.0 Lighting

Total number of light fittings	15
Total number of L.E.L. fittings	2

14.0 Main Heating1

PCDF boiler Reference	10328 Vaillant, Ecotec Pro, 88.80%
Main Heating Code	BGW Post 98 Combi condens. with auto ign.
Heat Emitter	Radiators
Heat pump age	Unknown
Fuel Type	Mains gas
Flue Type	Balanced
Fan Assisted Flue	Yes
Design flow temperature	Unknown
PCDF Heating Controls	0
Main Heating Controls	CBE Programmer, room thermostat and TRVs
PCDF Compensator	0
Percentage of Heat	100 %

RdSAP elmhurst energy systems

Summary Information

14.1 Main Heating2

PCDF boiler Reference	0
Main Heating Code	
Percentage of Heat	0 %

15.0 Water Heating

Water Heating Code	HWP From the primary heating system

15.1 Hot Water Cylinder

Hot Water Cylinder Present	No

16.0 Solar water heating

Solar Water Heating	No

17.0 Waste Water Heat Recovery System

Total Number of rooms with bath and/or shower	1
Number of rooms with mixer shower and no bath	0
Number of rooms with bath and mixer shower	1
Is WWHRS present in the property?	No / Unknown

18.0 Flue Gas Heat Recovery System

Present	No

19.0 Photovoltaic Panel

Photovoltaic Panel	None

20.0 Wind Turbine

Terrain Type	Suburban
Wind turbine present?	No

21.0 Other Details

Electricity meter type	Single
Main gas	Yes

RdSAP

elmhurst energy systems

Summary Information

Recommendations

- Loft insulation (Not applicable)
- Flat roof insulation (Recommended)
- Room-in-roof insulation (Not applicable)
- Cavity wall insulation (Recommended)
- Party wall insulation (Not applicable)
- Solid wall insulation (Not applicable)
- Floor insulation (solid floor) (SAP increase too small)
- Hot water cylinder insulation (Not applicable)
- Draught proofing (Already installed)
- Low energy lighting (Recommended)
- Cylinder thermostat (Not applicable)
- Heating controls for wet central heating system (Already installed)
- Upgrade boiler, same fuel (Already installed)
- Change heating to condensing gas condensing boiler (fuel switch) (Not applicable)
- Flue gas heat recovery in conjunction with new boiler (Not applicable)
- Solar water heating (Recommended)
- Heat recovery system for mixer showers (SAP increase too small)
- Double glazed windows (Already installed)
- Insulated doors (SAP increase too small)
- Solar photovoltaic panels (Recommended)
- Wind turbine (Not applicable)

Alternative Recommendations

- External wall insulation with cavity insulation (Alternative measure)
- Biomass boiler (alternative) (Not applicable)
- Air or ground source heat pump (alternative) (Not applicable)
- Air or ground source heat pump with underfloor heating (alternative) (Not applicable)
- Micro CHP (alternative) (Not applicable)

Related Party Disclosure

No related party

Addenda

— Any Wall Insulation Issues —

, Cavity wall insulation recommended (Ext1)Stone walls are present (Main)

Has the property any 'Access Issues' for potential wall insulation?	No
Has the property any 'narrow cavity(s)' (<50mm)?	No
Is the property in a 'high exposure' location?	No

DEA 9, EPC, Test Property 1

Energy Performance Certificate

HM Government

7, Stoney Lane, Chapelthorpe, WAKEFIELD, WF4 3JN

Dwelling type:	End-terrace house	**Reference number:**	8605-4167-6929-3196-2983
Date of assessment:	16 January 2018	**Type of assessment:**	RdSAP, existing dwelling
Date of certificate:	18 January 2018	**Total floor area:**	93 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

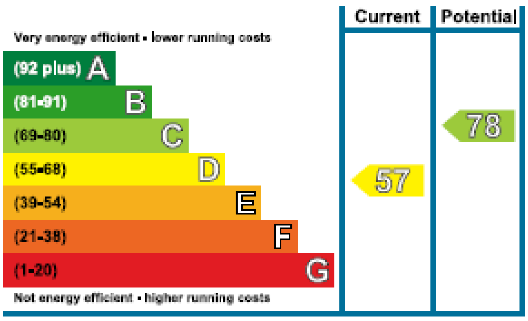
Estimated energy costs of dwelling for 3 years:	**£ 3,315**
Over 3 years you could save	**£ 906**

Estimated energy costs of this home

	Current costs	Potential costs	Potential future savings
Lighting	£ 267 over 3 years	£ 186 over 3 years	You could save £ 906 over 3 years
Heating	£ 2,736 over 3 years	£ 2,007 over 3 years	
Hot Water	£ 312 over 3 years	£ 216 over 3 years	
Totals	**£ 3,315**	**£ 2,409**	

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.

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

Recommended measures	Indicative cost	Typical savings over 3 years	Available with Green Deal
1 Flat roof or sloping ceiling insulation	£850 - £1,500	£ 141	✓
2 Cavity wall insulation	£500 - £1,500	£ 84	✓
3 Internal or external wall insulation	£4,000 - £14,000	£ 405	✓

See page 3 for a full list of recommendations for this property.

To find out more about the recommended measures and other actions you could take today to save money, visit www.gov.uk/energy-grants-calculator or call **0300 123 1234** (standard national rate). The Green Deal may enable you to make your home warmer and cheaper to run.

Summary of this home's energy performance related features

Element	Description	Energy Efficiency
Walls	Sandstone or limestone, as built, no insulation (assumed)	★☆☆☆☆
	Cavity wall, as built, no insulation (assumed)	★★☆☆☆
Roof	Pitched, no insulation (assumed)	★☆☆☆☆
	Flat, no insulation (assumed)	★☆☆☆☆
Floor	Solid, no insulation (assumed)	—
Windows	Fully double glazed	★★★☆☆
Main heating	Boiler and radiators, mains gas	★★★★☆
Main heating controls	Programmer and room thermostat	★★★☆☆
Secondary heating	Room heaters, wood logs	—
Hot water	From main system	★★★★☆
Lighting	Low energy lighting in 56% of fixed outlets	★★★★☆

Current primary energy use per square metre of floor area: 307 kWh/m² per year

The assessment does not take into consideration the physical condition of any element. 'Assumed' means that the insulation could not be inspected and an assumption has been made in the methodology based on age and type of construction.

See addendum on the last page relating to items in the table above.

Low and zero carbon energy sources

Low and zero carbon energy sources are sources of energy that release either very little or no carbon dioxide into the atmosphere when they are used. Installing these sources may help reduce energy bills as well as cutting carbon. The following low or zero carbon energy sources are provided for this home:

- Biomass secondary heating

Your home's heat demand

For most homes, the vast majority of energy costs derive from heating the home. Where applicable, this table shows the energy that could be saved in this property by insulating the loft and walls, based on typical energy use (shown within brackets as it is a reduction in energy use).

Heat demand	Existing dwelling	Impact of loft insulation	Impact of cavity wall insulation	Impact of solid wall insulation
Space heating (kWh per year)	16,634	(2,582)	(622)	(2,994)
Water heating (kWh per year)	2,216			

You could receive Renewable Heat Incentive (RHI) payments and help reduce carbon emissions by replacing your existing heating system with one that generates renewable heat, subject to meeting minimum energy efficiency requirements. The estimated energy required for space and water heating will form the basis of the payments. For more information, search for the domestic RHI on the www.gov.uk website.

Recommendations

The measures below will improve the energy performance of your dwelling. The performance ratings after improvements listed below are cumulative; that is, they assume the improvements have been installed in the order that they appear in the table. Further information about the recommended measures and other simple actions you could take today to save money is available at www.gov.uk/energy-grants-calculator. Before installing measures, you should make sure you have secured the appropriate permissions, where necessary. Such permissions might include permission from your landlord (if you are a tenant) or approval under Building Regulations for certain types of work.

Measures with a green tick ✔ may be supported through the Green Deal finance. If you want to take up measures with an orange tick ✔ through Green Deal finance, be aware you may need to contribute some payment up-front.

Recommended measures	Indicative cost	Typical savings per year	Rating after improvement	Green Deal finance
Flat roof or sloping ceiling insulation	£850 - £1,500	£ 47	D59	✔ (orange)
Cavity wall insulation	£500 - £1,500	£ 28	D60	✔ (orange)
Internal or external wall insulation	£4,000 - £14,000	£ 135	D65	✔ (green)
Low energy lighting for all fixed outlets	£35	£ 24	D66	
Heating controls (thermostatic radiator valves)	£350 - £450	£ 35	D67	✔ (orange)
Solar water heating	£4,000 - £6,000	£ 32	D68	✔ (orange)
Solar photovoltaic panels, 2.5 kWp	£5,000 - £8,000	£ 271	C78	✔ (orange)

Alternative measures

There are alternative measures below which you could also consider for your home.

- External insulation with cavity wall insulation

Opportunity to benefit from a Green Deal on this property

Green Deal Finance allows you to pay for some of the cost of your improvements in instalments under a Green Deal Plan (note that this is a credit agreement, but with instalments being added to the electricity bill for the property). The availability of a Green Deal Plan will depend upon your financial circumstances. There is a limit to how much Green Deal Finance can be used, which is determined by how much energy the improvements are estimated to **save** for a 'typical household'.

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Assessor's accreditation number:	EES/006272
Assessor's name:	Mr. Toby Gledhill
Phone number:	01924 249970
E-mail address:	toby@w-y-p.co.uk
Related party disclosure:	No related party

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One of the biggest contributors to global warming is carbon dioxide. The energy we use for heating, lighting and power in homes produces over a quarter of the UK's carbon dioxide emissions.

The average household causes about 6 tonnes of carbon dioxide every year. Based on this assessment, your home currently produces approximately 4.6 tonnes of carbon dioxide every year. Adopting the recommendations in this report can reduce emissions and protect the environment. If you were to install these recommendations you could reduce this amount by 2.3 tonnes per year. You could reduce emissions even more by switching to renewable energy sources.

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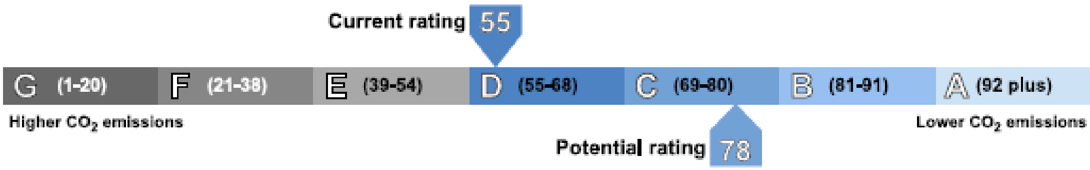

Addendum

This dwelling has stone walls and so requires further investigation to establish whether these walls are of cavity construction and to determine which type of cavity wall insulation is best suited.

DEA 9, EPC Inputs, Test Property 1

RdSAP

elmhurst energy systems

Summary Information

Surveyor:	C300-0001				
Name:	Toby Gledhill	Title: Mr.		Tel Number:	
Survey Reference:	000225	My Reference:			
Current SAP rating:	D 57	Potential SAP rating:	C 78	Emissions (t/year):	4.589 tonnes
Current EI rating:	D 55	Potential EI rating:	C 78	Fuel Bill:	£1105

Property Details:

RdSAP version:	SAP 9.93
Reference Number:	C300-0001-000225
My Reference:	
Lodgement Required:	Yes
Regs Region:	England
EPC Language:	English
UPRN:	2561619768
Postcode:	WF4 3JN
Region:	East Pennines
House Name:	
House No:	7
Street:	Stoney Lane
Locality:	Chapelthorpe
Town:	WAKEFIELD
County:	West Yorkshire
Property Tenure:	Owner-occupied
Transaction Type:	None of the above
Inspection Date:	16/01/2018
Process date:	18/01/2018

RdSAP Inputs

Property Description:

1.0 Property type:		H House
		E End-Terrace
2.0 Number of	Storeys:	2
	Habitable Rooms:	4
	Heated Habitable Rooms:	4
3.0 Date Built:	Main Property	A before 1900
	1st Extension	D 1950-1966

4.0 Dimensions:

Dimension type: Internal

	Floor Area [m2]	Room Height [m]	Heat Loss Wall Perimeter [m]	Party Wall Length [m]
Main Property				
1st Floor:	31.48	2.10	12.06	5.19
Lowest Floor:	25.97	2.21	11.45	5.19
1st Extension				
1st Floor:	12.44	2.20	7.08	3.24
Lowest Floor:	12.44	2.14	3.24	3.24

5.0 Conservatory:

Is there a conservatory?	Yes
Is it thermally separated?	No
Floor Area [m2]	10.97
Double Glazed	Yes
Glazed Perimeter [m]	3.12
Room Height	1 Storey

7.0 Walls:

Main Property

Type	SS Stone: sandstone or limestone
Insulation	A As Built
Dry-lining	No
Wall Thickness Unknown	No
Wall Thickness [mm]	480
U-value Known	No
Party Wall Type	U Unable to determine

Summary Information

1st Extension

As Main Wall	No
Type	CA Cavity
Insulation	A As Built
Dry-lining	No
Wall Thickness Unknown	No
Wall Thickness [mm]	300
U-value Known	No
Party Wall Type	U Unable to determine

8.0 Roofs:

Main Property

Type	PN Pitched (slates/tiles), no access
Insulation	U Unknown
U-value Known	No

1st Extension

As Main	No
Type	F Flat
Insulation Thickness	As Built
U-value Known	No

9.0 Floors:

Main Property

Location	G Ground floor
Type	S Solid
Insulation	A As built
U-value Known	No

1st Extension

As Main	No
Location	G Ground floor
Type	S Solid
Insulation	A As built
U-value Known	No

10.0 Doors:

Total Number of Doors	1
Number of Insulated Doors	0

11.0 Windows:

Glazed Area	T Typical
Proportion Double\Triple-glazed	100 %
Glazing	Double with unknown install date
Frame Type	PVC frame
Glazing Gap	12 mm
Draught Proofing	100 %

12.0 Ventilation & Cooling

No. of open Fireplaces	0
Mechanical Ventilation	No
Fixed Space Cooling	No

13.0 Lighting

Total number of light fittings	16
Total number of L.E.L. fittings	9

14.0 Main Heating1

PCDF boiler Reference	10328 Vaillant, Ecotec Pro, 88.80%
Main Heating Code	BGW Post 98 Combi condens. with auto ign.
Heat Emitter	Radiators
Heat pump age	Unknown
Fuel Type	Mains gas
Flue Type	Balanced
Fan Assisted Flue	Yes
Design flow temperature	Unknown
PCDF Heating Controls	0
Main Heating Controls	CBC Programmer and room thermostat
PCDF Compensator	0
Percentage of Heat	100 %

Summary Information

14.1 Main Heating2

PCDF boiler Reference	0
Main Heating Code	
Percentage of Heat	0 %
Secondary Heating Code	RWM Closed room heater

15.0 Water Heating

Water Heating Code	HWP From the primary heating system

15.1 Hot Water Cylinder

Hot Water Cylinder Present	No

16.0 Solar water heating

Solar Water Heating	No

17.0 Waste Water Heat Recovery System

Total Number of rooms with bath and/or shower	1
Number of rooms with mixer shower and no bath	0
Number of rooms with bath and mixer shower	1
Is WWHRS present in the property?	No / Unknown

18.0 Flue Gas Heat Recovery System

Present	No

19.0 Photovoltaic Panel

Photovoltaic Panel	None

20.0 Wind Turbine

Terrain Type	Suburban
Wind turbine present?	No

21.0 Other Details

Electricity meter type	Single
Main gas	Yes

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Summary Information

Recommendations

- Loft insulation (Not applicable)
- Flat roof insulation (Recommended)
- Room-in-roof insulation (Not applicable)
- Cavity wall insulation (Recommended)
- Party wall insulation (Not applicable)
- Solid wall insulation (Recommended)
- Floor insulation (solid floor) (SAP increase too small)
- Hot water cylinder insulation (Not applicable)
- Draught proofing (Already installed)
- Low energy lighting (Recommended)
- Cylinder thermostat (Not applicable)
- Heating controls for wet central heating system (Recommended)
- Upgrade boiler, same fuel (Already installed)
- Change heating to condensing gas condensing boiler (fuel switch) (Not applicable)
- Flue gas heat recovery in conjunction with new boiler (Not applicable)
- Solar water heating (Recommended)
- Heat recovery system for mixer showers (SAP increase too small)
- Double glazed windows (Already installed)
- Insulated doors (SAP increase too small)
- Solar photovoltaic panels (Recommended)
- Wind turbine (Not applicable)

Alternative Recommendations

- External wall insulation with cavity insulation (Alternative measure)
- Biomass boiler (alternative) (Not applicable)
- Air or ground source heat pump (alternative) (Not applicable)
- Air or ground source heat pump with underfloor heating (alternative) (Not applicable)
- Micro CHP (alternative) (Not applicable)

Related Party Disclosure

No related party

Addenda

--- Any Wall Insulation Issues ---

, Cavity wall insulation recommended (Ext1)Stone walls are present (Main)

Has the property any 'Access Issues' for potential wall insulation?	No
Has the property any 'narrow cavity(s)' (<50mm)?	No
Is the property in a 'high exposure' location?	No

DEA 10, EPC, Test Property 1

Energy Performance Certificate

HM Government

7, Stoney Lane, Chapelthorpe, WAKEFIELD, WF4 3JN

Dwelling type:	End-terrace house	**Reference number:**	8605-3177-6929-3126-2983
Date of assessment:	23 January 2018	**Type of assessment:**	RdSAP, existing dwelling
Date of certificate:	21 July 2018	**Total floor area:**	94 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

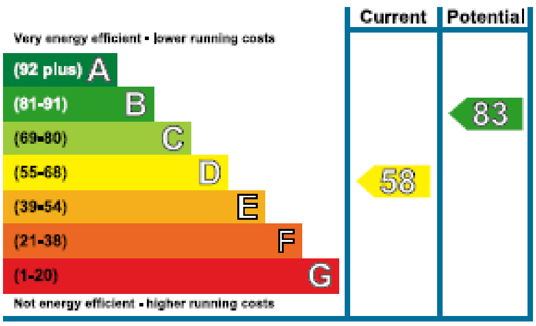
Estimated energy costs of dwelling for 3 years:	**£ 3,258**
Over 3 years you could save	**£ 1,218**

Estimated energy costs of this home

	Current costs	Potential costs	Potential future savings
Lighting	£ 282 over 3 years	£ 192 over 3 years	You could save £ 1,218 over 3 years
Heating	£ 2,670 over 3 years	£ 1,635 over 3 years	
Hot Water	£ 306 over 3 years	£ 213 over 3 years	
Totals	**£ 3,258**	**£ 2,040**	

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.

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

Recommended measures	Indicative cost	Typical savings over 3 years
1 Flat roof or sloping ceiling insulation	£850 - £1,500	£ 438
2 Internal or external wall insulation	£4,000 - £14,000	£ 606
3 Low energy lighting for all fixed outlets	£35	£ 81

See page 3 for a full list of recommendations for this property.

To find out more about the recommended measures and other actions you could take today to save money, visit www.gov.uk/energy-grants-calculator or call **0300 123 1234** (standard national rate). The Green Deal may enable you to make your home warmer and cheaper to run.

Summary of this home's energy performance related features

Element	Description	Energy Efficiency
Walls	Sandstone or limestone, as built, no insulation (assumed)	★☆☆☆☆
	Solid brick, as built, no insulation (assumed)	★☆☆☆☆
	Cavity wall, as built, insulated (assumed)	★★★★☆
Roof	Pitched, no insulation (assumed)	★☆☆☆☆
	Flat, insulated (assumed)	★★★☆☆
Floor	Solid, no insulation (assumed)	—
	To external air, no insulation (assumed)	—
Windows	Fully double glazed	★★★☆☆
Main heating	Boiler and radiators, mains gas	★★★★☆
Main heating controls	Programmer, room thermostat and TRVs	★★★★☆
Secondary heating	Room heaters, wood logs	—
Hot water	From main system	★★★★☆
Lighting	Low energy lighting in 53% of fixed outlets	★★★★☆

Current primary energy use per square metre of floor area: 301 kWh/m² per year

The assessment does not take into consideration the physical condition of any element. 'Assumed' means that the insulation could not be inspected and an assumption has been made in the methodology based on age and type of construction.

See addendum on the last page relating to items in the table above.

Low and zero carbon energy sources

Low and zero carbon energy sources are sources of energy that release either very little or no carbon dioxide into the atmosphere when they are used. Installing these sources may help reduce energy bills as well as cutting carbon. The following low or zero carbon energy sources are provided for this home:

- Biomass secondary heating

Your home's heat demand

For most homes, the vast majority of energy costs derive from heating the home. Where applicable, this table shows the energy that could be saved in this property by insulating the loft and walls, based on typical energy use (shown within brackets as it is a reduction in energy use).

Heat demand	Existing dwelling	Impact of loft insulation	Impact of cavity wall insulation	Impact of solid wall insulation
Space heating (kWh per year)	16,404	N/A	N/A	(4,060)
Water heating (kWh per year)	2,219			

You could receive Renewable Heat Incentive (RHI) payments and help reduce carbon emissions by replacing your existing heating system with one that generates renewable heat, subject to meeting minimum energy efficiency requirements. The estimated energy required for space and water heating will form the basis of the payments. For more information, search for the domestic RHI on the www.gov.uk website.

Recommendations

The measures below will improve the energy performance of your dwelling. The performance ratings after improvements listed below are cumulative; that is, they assume the improvements have been installed in the order that they appear in the table. Further information about the recommended measures and other simple actions you could take today to save money is available at www.gov.uk/energy-grants-calculator. Before installing measures, you should make sure you have secured the appropriate permissions, where necessary. Such permissions might include permission from your landlord (if you are a tenant) or approval under Building Regulations for certain types of work.

Recommended measures	Indicative cost	Typical savings per year	Rating after improvement
Flat roof or sloping ceiling insulation	£850 - £1,500	£ 146	D63
Internal or external wall insulation	£4,000 - £14,000	£ 202	C71
Low energy lighting for all fixed outlets	£35	£ 27	C72
Solar water heating	£4,000 - £6,000	£ 32	C73
Solar photovoltaic panels, 2.5 kWp	£5,000 - £8,000	£ 279	B83

Opportunity to benefit from a Green Deal on this property

Green Deal Finance allows you to pay for some of the cost of your improvements in instalments under a Green Deal Plan (note that this is a credit agreement, but with instalments being added to the electricity bill for the property). The availability of a Green Deal Plan will depend upon your financial circumstances. There is a limit to how much Green Deal Finance can be used, which is determined by how much energy the improvements are estimated to **save** for a 'typical household'.

You may be able to obtain support towards repairs or replacements of heating systems and/or basic insulation measures, if you are in receipt of qualifying benefits or tax credits. To learn more about this scheme and the rules about eligibility, call the Energy Saving Advice Service on **0300 123 1234** for England and Wales.

About this document and the data in it

This document has been produced following an energy assessment undertaken by a qualified Energy Assessor, accredited by Elmhurst Energy Systems Ltd. You can obtain contact details of the Accreditation Scheme at www.elmhurstenergy.co.uk.

A copy of this certificate has been lodged on a national register as a requirement under the Energy Performance of Buildings Regulations 2012 as amended. It will be made available via the online search function at www.epcregister.com. The certificate (including the building address) and other data about the building collected during the energy assessment but not shown on the certificate, for instance heating system data, will be made publicly available at www.opendatacommunities.org.

This certificate and other data about the building may be shared with other bodies (including government departments and enforcement agencies) for research, statistical and enforcement purposes. Any personal data it contains will be processed in accordance with the General Data Protection Regulation and all applicable laws and regulations relating to the processing of personal data and privacy. For further information about this and how data about the property are used, please visit www.epcregister.com. To opt out of having information about your building made publicly available, please visit www.epcregister.com/optout.

Assessor's accreditation number:	EES/006272
Assessor's name:	Mr. Toby Gledhill
Phone number:	01924 249970
E-mail address:	toby@w-y-p.co.uk
Related party disclosure:	No related party

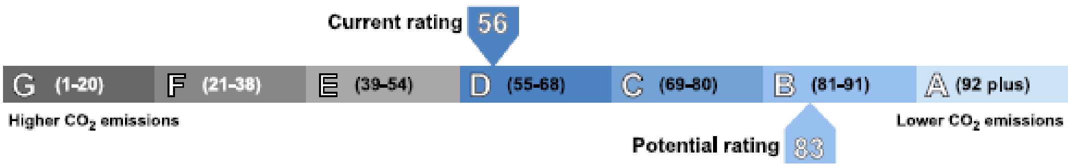
There is more information in the guidance document *Energy Performance Certificates for the marketing, sale and let of dwellings* available on the Government website at: www.gov.uk/government/collections/energy-performance-certificates. It explains the content and use of this document, advises on how to identify the authenticity of a certificate and how to make a complaint.

About the impact of buildings on the environment

One of the biggest contributors to global warming is carbon dioxide. The energy we use for heating, lighting and power in homes produces over a quarter of the UK's carbon dioxide emissions.

The average household causes about 6 tonnes of carbon dioxide every year. Based on this assessment, your home currently produces approximately 4.5 tonnes of carbon dioxide every year. Adopting the recommendations in this report can reduce emissions and protect the environment. If you were to install these recommendations you could reduce this amount by 2.7 tonnes per year. You could reduce emissions even more by switching to renewable energy sources.

The environmental impact rating is a measure of a home's impact on the environment in terms of carbon dioxide (CO_2) emissions based on standardised assumptions about occupancy and energy use. The higher the rating the less impact it has on the environment.



Addendum

This dwelling has stone walls and so requires further investigation to establish whether these walls are of cavity construction and to determine which type of cavity wall insulation is best suited.

DEA 10, EPC Inputs, Test Property 1

RdSAP

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Summary Information

Surveyor:	C300-0001				
Name:	Toby Gledhill		Title: Mr.	Tel Number:	
Survey Reference:	000272		My Reference:		
Current SAP rating:	D 58	Potential SAP rating:	B 83	Emissions (t/year):	4.547 tonnes
Current EI rating:	D 56	Potential EI rating:	B 83	Fuel Bill:	£1086

Property Details:

RdSAP version:	SAP 9.93
Reference Number:	C300-0001-000272
My Reference:	
Lodgement Required:	Yes
Regs Region:	England
EPC Language:	English
UPRN:	2561619768
Postcode:	WF4 3JN
Region:	East Pennines
House Name:	
House No:	7
Street:	Stoney Lane
Locality:	Chapelthorpe
Town:	WAKEFIELD
County:	West Yorkshire
Property Tenure:	Owner-occupied
Transaction Type:	None of the above
Inspection Date:	23/01/2018
Process date:	21/07/2018

RdSAP Inputs

Property Description:

1.0 Property type:		H House E End-Terrace
2.0 Number of	Storeys:	2
	Habitable Rooms:	4
	Heated Habitable Rooms:	4
3.0 Date Built	Main Property	A before 1900
	1st Extension	H 1991-1995
	2nd Extension	A before 1900

4.0 Dimensions:

Dimension type: Internal

	Floor Area [m2]	Room Height [m]	Heat Loss Wall Perimeter [m]	Party Wall Length [m]
Main Property				
1st Floor:	26.41	2.67	7.46	4.70
Lowest Floor:	26.08	2.24	10.26	5.19
1st Extension				
1st Floor:	12.25	2.30	10.26	0.00
Lowest Floor:	12.44	2.30	3.24	3.24
2nd Extension				
1st Floor:	0.00	0.00	0.00	0.00
Lowest Floor:	5.59	2.67	7.08	0.00

5.0 Conservatory:

Is there a conservatory?	Yes
Is it thermally separated?	No
Floor Area [m2]	11.27
Double Glazed	Yes
Glazed Perimeter [m]	2.85
Room Height	1 Storey

Summary Information

7.0 Walls:

Main Property

Type	SS Stone: sandstone or limestone
Insulation	A As Built
Dry-lining	No
Wall Thickness Unknown	No
Wall Thickness [mm]	420
U-value Known	No
Alternative Wall Area [m2]	10.39
Alternative Type	SO Solid Brick
Alternative Insulation	A As Built
Alternative Dry-lining	No
Alternative Wall Thickness Unknown	Yes
Alternative Wall Thickness	220
Alternative U-value Known	No
Party Wall Type	U Unable to determine

1st Extension

As Main Wall	No
Type	CA Cavity
Insulation	A As Built
Wall Thickness Unknown	No
Wall Thickness [mm]	320
U-value Known	No
Party Wall Type	U Unable to determine

2nd Extension

As Main Wall	Yes
Type	SS Stone: sandstone or limestone
Insulation	A As Built
Dry-lining	No
Wall Thickness Unknown	No
Wall Thickness [mm]	420
U-value Known	No

8.0 Roofs:

Main Property

Type	PS Pitched, sloping ceiling
Insulation Thickness	As Built
U-value Known	No

1st Extension

As Main	No
Type	F Flat
Insulation Thickness	As Built
U-value Known	No

2nd Extension

As Main	Yes
Type	PS Pitched, sloping ceiling
Insulation Thickness	As Built
U-value Known	No

9.0 Floors:

Main Property

Location	G Ground floor
Type	S Solid
Insulation	A As built
U-value Known	No

1st Extension

As Main	No
Location	G Ground floor
Type	S Solid
Insulation	A As built
U-value Known	No

Summary Information

2nd Extension

As Main	No
Location	E To external air
Type	T Suspended timber
Insulation	A As built
U-value Known	No

10.0 Doors:

Total Number of Doors	1
Number of Insulated Doors	0

11.0 Windows:

Glazed Area — MM Much More than typical

Area	Glazing Type	Frame Type	Glazing Gap	Location	Orientation	Data-Source	U-value	g-value
1.20	Double pre 2002	Non-PVC frame		Main construction	North	Manufacturer	3.10	0.76
0.72	Double pre 2002	Non-PVC frame		Main construction	South East	Manufacturer	3.10	0.76
1.20	Double pre 2002	Non-PVC frame		Main construction	North	Manufacturer	3.10	0.76
0.72	Double pre 2002	Non-PVC frame		Main construction	South	Manufacturer	3.10	0.76
0.48	Double pre 2002	Non-PVC frame		Extension 2	North	Manufacturer	3.10	0.76
2.70	Double pre 2002	PVC frame	12 mm	Extension 1	East	Manufacturer	2.80	0.76
1.80	Double pre 2002	PVC frame	12 mm	Extension 1	South	Manufacturer	2.80	0.76
2.70	Double pre 2002	PVC frame	12 mm	Extension 1	South	Manufacturer	2.80	0.76
1.80	Double pre 2002	PVC frame	12 mm	Extension 1	East	Manufacturer	2.80	0.76

Draught Proofing — 100 %

12.0 Ventilation & Cooling

No. of open Fireplaces	0
Mechanical Ventilation	No
Fixed Space Cooling	No

13.0 Lighting

Total number of light fittings	15
Total number of L.E.L. fittings	8

14.0 Main Heating1

PCDF boiler Reference	10328 Vaillant, Ecotec Pro, 88.80%
Main Heating Code	BGW Post 98 Combi condens. with auto ign.
Heat Emitter	Radiators
Heat pump age	Unknown
Fuel Type	Mains gas
Flue Type	Balanced
Fan Assisted Flue	Yes
Design flow temperature	Unknown
PCDF Heating Controls	0
Main Heating Controls	CBE Programmer, room thermostat and TRVs
PCDF Compensator	0
Percentage of Heat	100 %

14.1 Main Heating2

PCDF boiler Reference	0
Main Heating Code	
Percentage of Heat	0 %

Secondary Heating Code	RWM Closed room heater

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Summary Information

15.0 Water Heating

Water Heating Code	HWP From the primary heating system

15.1 Hot Water Cylinder

Hot Water Cylinder Present	No

16.0 Solar water heating

Solar Water Heating	No

17.0 Waste Water Heat Recovery System

Total Number of rooms with bath and/or shower	1
Number of rooms with mixer shower and no bath	0
Number of rooms with bath and mixer shower	1
Is WWHRS present in the property?	No / Unknown

18.0 Flue Gas Heat Recovery System

Present	No

19.0 Photovoltaic Panel

Photovoltaic Panel	None

20.0 Wind Turbine

Terrain Type	Suburban
Wind turbine present?	No

21.0 Other Details

Electricity meter type	Single
Main gas	Yes

RdSAP

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Summary Information

Recommendations

Loft insulation (Not applicable)
Flat roof insulation (Recommended)
Room-in-roof insulation (Not applicable)
Cavity wall insulation (Already installed)
Party wall insulation (Not applicable)
Solid wall insulation (Recommended)
Floor insulation (suspended floor) (SAP increase too small)
Hot water cylinder insulation (Not applicable)
Draught proofing (Already installed)
Low energy lighting (Recommended)
Cylinder thermostat (Not applicable)
Heating controls for wet central heating system (Already installed)
Upgrade boiler, same fuel (Already installed)
Change heating to condensing gas condensing boiler (fuel switch) (Not applicable)
Flue gas heat recovery in conjunction with new boiler (Not applicable)
Solar water heating (Recommended)
Heat recovery system for mixer showers (SAP increase too small)
Double glazed windows (Already installed)
Insulated doors (SAP increase too small)
Solar photovoltaic panels (Recommended)
Wind turbine (Not applicable)

Alternative Recommendations
External wall insulation with cavity insulation (Not applicable)
Biomass boiler (alternative) (Not applicable)
Air or ground source heat pump (alternative) (Not applicable)
Air or ground source heat pump with underfloor heating (alternative) (Not applicable)
Micro CHP (alternative) (Not applicable)

Related Party Disclosure

No related party

Addenda

— Any Wall Insulation Issues —

Has the property any 'Access Issues' for potential wall insulation?	No
Is the property in a 'high exposure' location?	No

Appendix I: Test Property 1 Photo Set, Images 1-13

Image 1. Control property for phase 1 of the EPC site study.

Image 2. Rear elevation of control property for phase 1 of the EPC study, showing two storey circa 1970 extension, and glazed kitchen extension beyond this. The building that adjoins the kitchen extension to the left hand side of this photograph belongs to the neighbouring property.

Image 3. Passageway underneath the property. The main bedroom sits partly over this passageway.

Image 4. The glazed single storey kitchen extension, which adjoins the neighbouring property to the side and rear.

Image 5. Wall thickness of the main sandstone dwelling wall, measuring 480mm total.

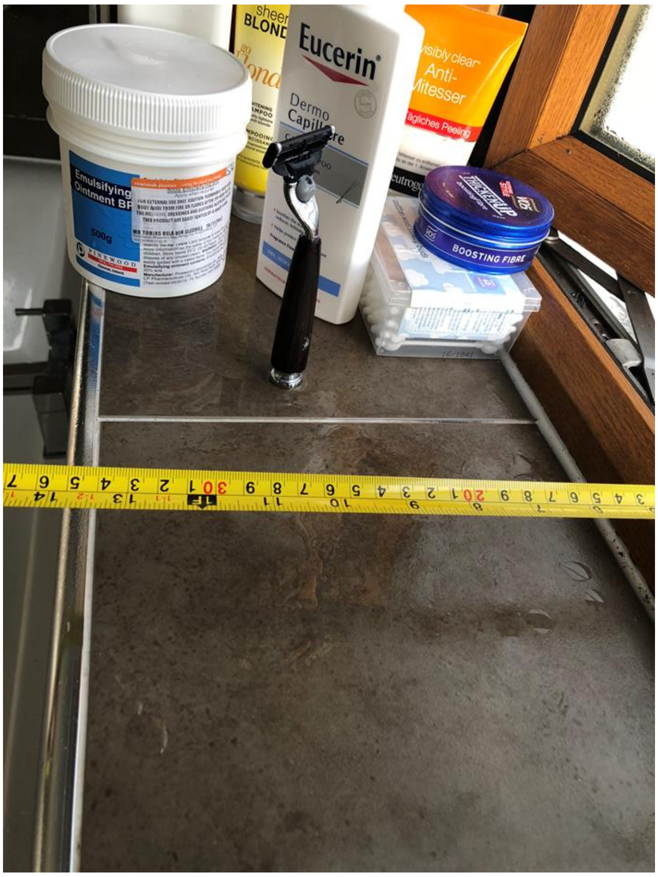


Image 6. Wall thickness of the extension wall, measuring 350mm

Image 7. The vaulted first floor ceiling to the original dwelling is an unusual feature, which may not be considered representative of the wider UK housing stock. This was a feature considered reasonable to test the DEA’s ability, the justification for which is that many properties may have a small number of interesting or unusual features that may have warranted some further investigation.

Image 8. Condensing combination boiler, located in the front bedroom. Make and model are clearly identifiable toward the bottom left hand corner of the photograph, and the model ‘qualifier’ (the specific model type) is visible on the sticker toward the top right hand corner of the photograph

Image 9. ‘Smart’ digital thermostats, such as the ‘Nest’ shown here, are becoming commonplace now. This may be considered a standard feature for time and temperature control in a typical UK home.

Image 10. Thermostatic radiator valves, or ‘TRVs’ are common. These allow the temperature of individual rooms to be adjusted, while the smart thermostat will control the overall temperature of the dwelling from its central location.

Image 11. Solid fuel ‘closed’ heater, or stove, cited in the living room.

Image 12. The glazing gap is requested within RdSAP, as this can denote the efficiency, and possibly also the age of the glazing.

Image 13. Finally, a breakdown of fixed light fittings and low energy bulbs is requested within RdSAP.

Appendix J: Control Property 1 Audit Feedback

D

Wed 28/02/2018 12:25

dea-qa@elmhurstenergy.co.uk

Elmhurst QA EPC Relodgement Feedback

To toby@w-y-p.co.uk

Cc dea-qa@elmhurstenergy.co.uk

ACCREDITATION SCHEME QUALITY ASSURANCE - AUDIT FEEDBACK

Surveyor ID Number: **C300-0001**

Original EPC Reference Number: **C300-0001-000224**
Original Report Reference Number (RRN): **9168-2016-6269-7098-1954**
Replacement Report Reference Number (RRN): **8428-6129-7160-5966-6996**
Property Address: **7, Stoney Lane, Chapelthorpe, WAKEFIELD, WF4 3JN**

Thank you for submitting your relodged survey for the above Quality Assurance audit. I am writing to inform you of the result of the audit as follows:

Result: Acceptable
Observations: Alteration to wall completed.

If the above result is 'Acceptable', no further action is required as your audit has met the required standard. However, if the result is 'Not Acceptable' your accreditation will be suspended immediately and you will need to contact us on 01455 883257 to arrange to relodge the EPC again.

Should you have any queries regarding your QA audit result, please contact our Existing Dwellings Team on 01455 883257 or existingdwellings-support@elmhurstenergy.co.uk

Yours sincerely

Quality Assurance Team
Elmhurst Energy Systems Ltd

T: 01455 883 257

www.elmhurstenergy.co.uk

Appendix J: Control Property 1 Inputs

RdSAP | elmhurst energy systems

Summary Information

Surveyor:	C300-0001				
Name:	Toby Gledhill	Title: Mr.		Tel Number:	
Survey Reference:	000239	My Reference:			
Current SAP rating:	D 57	Potential SAP rating:	B 82	Emissions (t/year):	5.317 tonnes
Current EI rating:	E 50	Potential EI rating:	C 79	Fuel Bill:	£1123

Property Details:

RdSAP version:	SAP 9.93
Reference Number:	C300-0001-000239
My Reference:	
Lodgement Required:	Yes
Regs Region:	England
EPC Language:	English
UPRN:	2561619768
Postcode:	WF4 3JN
Region:	East Pennines
House Name:	
House No:	7
Street:	Stoney Lane
Locality:	Chapelthorpe
Town:	WAKEFIELD
County:	West Yorkshire
Property Tenure:	Owner-occupied
Transaction Type:	None of the above
Inspection Date:	16/01/2018
Process date:	19/02/2018

RdSAP Inputs

Property Description:

1.0 Property type:		H House
		E End-Terrace
2.0 Number of	Storeys:	2
	Habitable Rooms:	4
	Heated Habitable Rooms:	4
3.0 Date Built:	Main Property	A before 1900
	1st Extension	D 1950-1966
	2nd Extension	A before 1900

4.0 Dimensions:

Dimension type: Internal

	Floor Area [m2]	Room Height [m]	Heat Loss Wall Perimeter [m]	Party Wall Length [m]
Main Property				
1st Floor:	25.93	2.43	7.12	4.63
Lowest Floor:	25.93	2.23	11.15	5.23
1st Extension				
1st Floor:	13.07	2.29	10.53	0.00
Lowest Floor:	13.07	2.14	3.26	3.26
2nd Extension				
1st Floor:	0.00	0.00	0.00	0.00
Lowest Floor:	5.55	2.43	7.03	0.00

5.0 Conservatory:

Is there a conservatory?	Yes
Is it thermally separated?	No
Floor Area [m2]	11.92
Double Glazed	Yes
Glazed Perimeter [m]	2.87
Room Height	1 Storey

RdSAP

elmhurst energy systems

Summary Information

1st Extension	
As Main	Yes
Location	G Ground floor
Type	S Solid
Insulation	A As built
U-value Known	No
2nd Extension	
As Main	No
Location	E To external air
Type	T Suspended timber
Insulation	A As built
U-value Known	No

10.0 Doors:

Total Number of Doors	2
Number of Insulated Doors	0

11.0 Windows:

Glazed Area	T Typical
Proportion Double\Triple-glazed	100 %
Glazing	Double with unknown install date
Frame Type	PVC frame
Glazing Gap	16 mm or more
Draught Proofing	100 %

12.0 Ventilation & Cooling

No. of open Fireplaces	0
Mechanical Ventilation	No
Fixed Space Cooling	No

13.0 Lighting

Total number of light fittings	26
Total number of L.E.L. fittings	22

14.0 Main Heating1

PCDF boiler Reference	10328 Vaillant, Ecotec Pro, 88.80%
Main Heating Code	BGW Post 98 Combi condens. with auto ign.
Heat Emitter	Radiators
Heat pump age	Unknown
Fuel Type	Mains gas
Flue Type	Balanced
Fan Assisted Flue	Yes
Design flow temperature	Unknown
PCDF Heating Controls	0
Main Heating Controls	CBE Programmer, room thermostat and TRVs
PCDF Compensator	0
Percentage of Heat	100 %

14.1 Main Heating2

PCDF boiler Reference	0
Main Heating Code	
Percentage of Heat	0 %
Secondary Heating Code	RDM Closed room heater

15.0 Water Heating

Water Heating Code	HWP From the primary heating system

15.1 Hot Water Cylinder

Hot Water Cylinder Present	No

16.0 Solar water heating

Solar Water Heating	No

Summary Information

17.0 Waste Water Heat Recovery System

Total Number of rooms with bath and/or shower	1
Number of rooms with mixer shower and no bath	0
Number of rooms with bath and mixer shower	1
Is WWHRS present in the property?	No / Unknown

18.0 Flue Gas Heat Recovery System

Present	No

19.0 Photovoltaic Panel

Photovoltaic Panel	None

20.0 Wind Turbine

Terrain Type	Suburban
Wind turbine present?	No

21.0 Other Details

Electricity meter type	Single
Main gas	Yes

RdSAP

elmhurst energy systems

Summary Information

Recommendations

- Loft insulation (Not applicable)
- Flat roof insulation (Recommended)
- Room-in-roof insulation (Not applicable)
- Cavity wall insulation (Recommended)
- Party wall insulation (Not applicable)
- Solid wall insulation (Recommended)
- Floor insulation (suspended floor) (SAP increase too small)
- Hot water cylinder insulation (Not applicable)
- Draught proofing (Already installed)
- Low energy lighting (SAP increase too small)
- Cylinder thermostat (Not applicable)
- Heating controls for wet central heating system (Already installed)
- Upgrade boiler, same fuel (Already installed)
- Change heating to condensing gas condensing boiler (fuel switch) (Not applicable)
- Flue gas heat recovery in conjunction with new boiler (Not applicable)
- Solar water heating (Recommended)
- Heat recovery system for mixer showers (SAP increase too small)
- Double glazed windows (Already installed)
- Insulated doors (SAP increase too small)
- Solar photovoltaic panels (Recommended)
- Wind turbine (Not applicable)

Alternative Recommendations

- External wall insulation with cavity insulation (Alternative measure)
- Biomass boiler (alternative) (Not applicable)
- Air or ground source heat pump (alternative) (Not applicable)
- Air or ground source heat pump with underfloor heating (alternative) (Not applicable)
- Micro CHP (alternative) (Not applicable)

Related Party Disclosure

Residing at the property

Addenda

— Any Wall Insulation Issues —

, Cavity wall insulation recommended (Ext1)Stone walls are present (, MainExt2)

Has the property any 'Access Issues' for potential wall insulation?	No
Has the property any 'narrow cavity(s)' (<50mm)?	No
Is the property in a 'high exposure' location?	No

Appendix K EPCS AND EPC INPUTS FOR DEAS 1 – 10, TEST PROPERTY 2

DEA 1 EPC, Test Property 2

Energy Performance Certificate

HM Government

11, Grosvenor Park, YORK, YO30 6BX

Dwelling type:	Mid-terrace house	**Reference number:**	9078-9041-7292-5831-7944
Date of assessment:	13 February 2019	**Type of assessment:**	RdSAP, existing dwelling
Date of certificate:	13 February 2019	**Total floor area:**	149 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

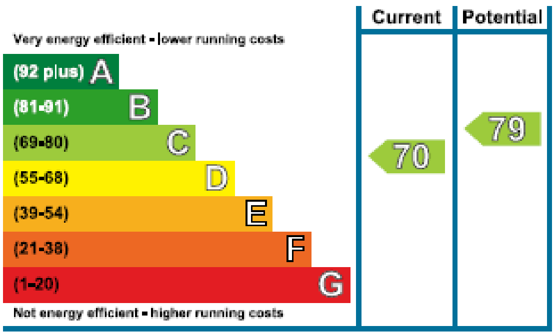
Estimated energy costs of dwelling for 3 years:	**£ 3,276**
Over 3 years you could save	**£ 168**

Estimated energy costs of this home

	Current costs	Potential costs	Potential future savings
Lighting	£ 474 over 3 years	£ 285 over 3 years	You could save £ 168 over 3 years
Heating	£ 2,463 over 3 years	£ 2,484 over 3 years	
Hot Water	£ 339 over 3 years	£ 339 over 3 years	
Totals	**£ 3,276**	**£ 3,108**	

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.

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

Recommended measures	Indicative cost	Typical savings over 3 years
1 Low energy lighting for all fixed outlets	£60	£ 168
2 Solar photovoltaic panels, 2.5 kWp	£5,000 - £8,000	£ 924

To find out more about the recommended measures and other actions you could take today to save money, visit www.gov.uk/energy-grants-calculator or call **0300 123 1234** (standard national rate). The Green Deal may enable you to make your home warmer and cheaper to run.

Summary of this home's energy performance related features

Element	Description	Energy Efficiency
Walls	Timber frame, as built, insulated (assumed)	★★★★☆
Roof	Pitched, 200 mm loft insulation	★★★★☆
Floor	Solid, limited insulation (assumed)	—
	To unheated space, limited insulation (assumed)	—
Windows	Fully double glazed	★★★☆☆
Main heating	Boiler and radiators, mains gas	★★★★☆
Main heating controls	Programmer, room thermostat and TRVs	★★★★☆
Secondary heating	None	—
Hot water	From main system	★★★★☆
Lighting	Low energy lighting in 33% of fixed outlets	★★★☆☆

Current primary energy use per square metre of floor area: 191 kWh/m² per year

The assessment does not take into consideration the physical condition of any element. 'Assumed' means that the insulation could not be inspected and an assumption has been made in the methodology based on age and type of construction.

Low and zero carbon energy sources

Low and zero carbon energy sources are sources of energy that release either very little or no carbon dioxide into the atmosphere when they are used. Installing these sources may help reduce energy bills as well as cutting carbon. There are none provided for this home.

Your home's heat demand

For most homes, the vast majority of energy costs derive from heating the home. Where applicable, this table shows the energy that could be saved in this property by insulating the loft and walls, based on typical energy use (shown within brackets as it is a reduction in energy use).

Heat demand	Existing dwelling	Impact of loft insulation	Impact of cavity wall insulation	Impact of solid wall insulation
Space heating (kWh per year)	14,727	N/A	N/A	N/A
Water heating (kWh per year)	2,356			

You could receive Renewable Heat Incentive (RHI) payments and help reduce carbon emissions by replacing your existing heating system with one that generates renewable heat, subject to meeting minimum energy efficiency requirements. The estimated energy required for space and water heating will form the basis of the payments. For more information, search for the domestic RHI on the www.gov.uk website.

Recommendations

The measures below will improve the energy performance of your dwelling. The performance ratings after improvements listed below are cumulative; that is, they assume the improvements have been installed in the order that they appear in the table. Further information about the recommended measures and other simple actions you could take today to save money is available at www.gov.uk/energy-grants-calculator. Before installing measures, you should make sure you have secured the appropriate permissions, where necessary. Such permissions might include permission from your landlord (if you are a tenant) or approval under Building Regulations for certain types of work.

Recommended measures	Indicative cost	Typical savings per year	Rating after improvement
Low energy lighting for all fixed outlets	£60	£ 56	C71
Solar photovoltaic panels, 2.5 kWp	£5,000 - £8,000	£ 308	C79

Opportunity to benefit from a Green Deal on this property

Green Deal Finance allows you to pay for some of the cost of your improvements in instalments under a Green Deal Plan (note that this is a credit agreement, but with instalments being added to the electricity bill for the property). The availability of a Green Deal Plan will depend upon your financial circumstances. There is a limit to how much Green Deal Finance can be used, which is determined by how much energy the improvements are estimated to **save** for a 'typical household'.

You may be able to obtain support towards repairs or replacements of heating systems and/or basic insulation measures, if you are in receipt of qualifying benefits or tax credits. To learn more about this scheme and the rules about eligibility, call the Energy Saving Advice Service on **0300 123 1234** for England and Wales.

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This certificate and other data about the building may be shared with other bodies (including government departments and enforcement agencies) for research, statistical and enforcement purposes. Any personal data it contains will be processed in accordance with the General Data Protection Regulation and all applicable laws and regulations relating to the processing of personal data and privacy. For further information about this and how data about the property are used, please visit www.epcregister.com. To opt out of having information about your building made publicly available, please visit www.epcregister.com/optout.

Assessor's accreditation number:	EES/006272
Assessor's name:	Mr. Toby Gledhill
Phone number:	01924 249970
E-mail address:	toby@w-y-p.co.uk
Related party disclosure:	No related party

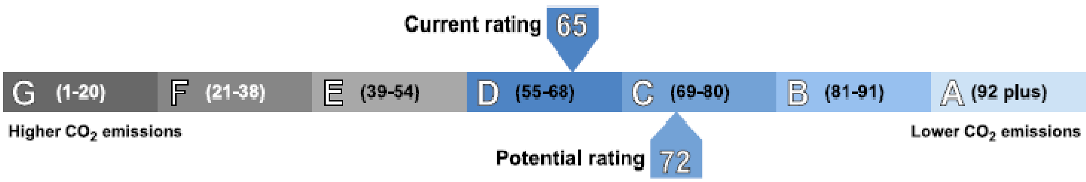
There is more information in the guidance document *Energy Performance Certificates for the marketing, sale and let of dwellings* available on the Government website at: www.gov.uk/government/collections/energy-performance-certificates. It explains the content and use of this document, advises on how to identify the authenticity of a certificate and how to make a complaint.

About the impact of buildings on the environment

One of the biggest contributors to global warming is carbon dioxide. The energy we use for heating, lighting and power in homes produces over a quarter of the UK's carbon dioxide emissions.

The average household causes about 6 tonnes of carbon dioxide every year. Based on this assessment, your home currently produces approximately 5.0 tonnes of carbon dioxide every year. Adopting the recommendations in this report can reduce emissions and protect the environment. If you were to install these recommendations you could reduce this amount by 1.0 tonnes per year. You could reduce emissions even more by switching to renewable energy sources.

The environmental impact rating is a measure of a home's impact on the environment in terms of carbon dioxide (CO_2) emissions based on standardised assumptions about occupancy and energy use. The higher the rating the less impact it has on the environment.



DEA 1, EPC Inputs, Test Property 2

RdSAP elmhurst energy

elmhurst energy systems

Summary Information

Surveyor:	C300-0001				
Name:	Toby Gledhill	**Title:** Mr.		**Tel Number:** 01904593570	
Survey Reference:	000295	**My Reference:**		21927	
Current SAP rating:	C 70	**Potential SAP rating:**	C 79	**Emissions (t/year):**	5.016 tonnes
Current EI rating:	D 65	**Potential EI rating:**	C 72	**Fuel Bill:**	£1092

Property Details:

RdSAP version:	SAP 9.93
Reference Number:	C300-0001-000295
My Reference:	21927
Lodgement Required:	Yes
Regs Region:	England
EPC Language:	English
UPRN:	9494173578
Postcode:	YO30 6BX
Region:	North East England
House Name:	
House No:	11
Street:	Grosvenor Park
Locality:	
Town:	YORK
County:	
Property Tenure:	Owner-occupied
Transaction Type:	None of the above
Inspection Date:	13/02/2019
Process date:	13/02/2019

RdSAP Inputs

Property Description:

1.0 Property type:		H House
		M Mid-Terrace
2.0 Number of	**Storeys:**	3
	Habitable Rooms:	5
	Heated Habitable Rooms:	5
3.0 Date Built:	**Main Property**	I 1996-2002
	1st Extension	I 1996-2002

4.0 Dimensions:

Dimension type: Internal

	Floor Area [m2]	Room Height [m]	Heat Loss Wall Perimeter [m]	Party Wall Length [m]
Main Property				
2nd Floor:	36.19	2.87	7.73	14.17
1st Floor:	36.19	2.55	7.73	14.17
Lowest Floor:	36.19	2.57	13.99	14.17
1st Extension				
2nd Floor:	0.00	0.00	0.00	0.00
1st Floor:	17.13	2.87	3.01	5.69
Lowest Floor:	17.13	2.55	3.01	5.69

5.0 Conservatory:

Is there a conservatory?	Yes
Is it thermally separated?	No
Floor Area [m2]	6.55
Double Glazed	Yes
Glazed Perimeter [m]	7.81
Room Height	1.5 Storey

RdSAP elmhurst energy

elmhurst energy systems

Summary Information

7.0 Walls:

Main Property

Type	TI Timber Frame
Insulation	A As Built
Wall Thickness Unknown	No
Wall Thickness [mm]	270
U-value Known	No
Party Wall Type	U Unable to determine

1st Extension

As Main Wall	Yes
Type	TI Timber Frame
Insulation	A As Built
Wall Thickness Unknown	No
Wall Thickness [mm]	270
U-value Known	No
Party Wall Type	U Unable to determine

8.0 Roofs:

Main Property

Type	PA Pitched (slates/tiles), access to loft
Insulation	J Joists
Insulation Thickness	200 mm
U-value Known	No

1st Extension

As Main	Yes
Type	PA Pitched (slates/tiles), access to loft
Insulation	J Joists
Insulation Thickness	200 mm
U-value Known	No

9.0 Floors:

Main Property

Location	G Ground floor
Type	S Solid
Insulation	A As built
U-value Known	No

1st Extension

As Main	No
Location	U Above unheated space
Type	T Suspended timber
Insulation	A As built
U-value Known	No

10.0 Doors:

Total Number of Doors	1
Number of Insulated Doors	0

11.0 Windows:

Glazed Area	T Typical
Proportion Double\Triple-glazed	100 %
Glazing	Double with unknown install date
Frame Type	Non-PVC frame
Draught Proofing	100 %

12.0 Ventilation & Cooling

No. of open Fireplaces	0
Mechanical Ventilation	No
Fixed Space Cooling	No

RdSAP elmhurst energy

elmhurst energy systems

Summary Information

13.0 Lighting

Total number of light fittings	18
Total number of L.E.L. fittings	6

14.0 Main Heating1

PCDF boiler Reference	8140 Powermax, 155x, 82.00%
Main Heating Code	CGB CPSU with auto ign.
Heat Emitter	Radiators
Heat pump age	Unknown
Fuel Type	Mains gas
Flue Type	Balanced
Fan Assisted Flue	Yes
PCDF Heating Controls	0
Main Heating Controls	CBE Programmer, room thermostat and TRVs
PCDF Compensator	0
Percentage of Heat	100 %

14.1 Main Heating2

PCDF boiler Reference	0
Main Heating Code	
Percentage of Heat	0 %

15.0 Water Heating

Water Heating Code	HWP From the primary heating system

15.1 Hot Water Cylinder

Hot Water Cylinder Present	Yes

16.0 Solar water heating

Solar Water Heating	No

17.0 Waste Water Heat Recovery System

Total Number of rooms with bath and/or shower	2
Number of rooms with mixer shower and no bath	1
Number of rooms with bath and mixer shower	1
Is WWHRS present in the property?	No / Unknown

18.0 Flue Gas Heat Recovery System

Present	No

19.0 Photovoltaic Panel

Photovoltaic Panel	None

20.0 Wind Turbine

Terrain Type	Suburban
Wind turbine present?	No

21.0 Other Details

Electricity meter type	Dual
Main gas	Yes

DEA 2 EPC, Test Property 2

Energy Performance Certificate

HM Government

11, Grosvenor Park, YORK, YO30 6BX

Dwelling type:	Mid-terrace house	**Reference number:**	8691-7727-5490-4371-1906
Date of assessment:	09 March 2019	**Type of assessment:**	RdSAP, existing dwelling
Date of certificate:	11 March 2019	**Total floor area:**	153 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

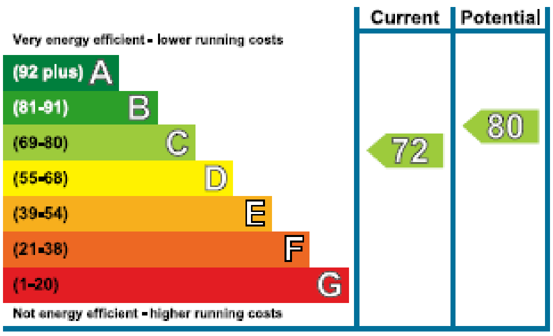
Estimated energy costs of dwelling for 3 years:	**£ 3,144**
Over 3 years you could save	**£ 153**

Estimated energy costs of this home

	Current costs	Potential costs	Potential future savings
Lighting	£ 432 over 3 years	£ 258 over 3 years	You could save £ 153 over 3 years
Heating	£ 2,373 over 3 years	£ 2,394 over 3 years	
Hot Water	£ 339 over 3 years	£ 339 over 3 years	
Totals	**£ 3,144**	**£ 2,991**	

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.

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

Recommended measures	Indicative cost	Typical savings over 3 years
1 Low energy lighting for all fixed outlets	£100	£ 153
2 Solar photovoltaic panels, 2.5 kWp	£5,000 - £8,000	£ 876

To find out more about the recommended measures and other actions you could take today to save money, visit www.gov.uk/energy-grants-calculator or call **0300 123 1234** (standard national rate). The Green Deal may enable you to make your home warmer and cheaper to run.

11, Grosvenor Park, , , YORK, YO30 6BX
11 March 2019 RRN: 8691-7727-5490-4371-1906 **Energy Performance Certificate**

Summary of this home's energy performance related features

Element	Description	Energy Efficiency
Walls	Timber frame, as built, insulated (assumed)	★★★★☆
Roof	Pitched, 250 mm loft insulation	★★★★☆
Floor	Solid, limited insulation (assumed)	—
	To unheated space, limited insulation (assumed)	—
Windows	Fully double glazed	★★★☆☆
Main heating	Boiler and radiators, mains gas	★★★★☆
Main heating controls	Programmer, room thermostat and TRVs	★★★★☆
Secondary heating	None	—
Hot water	From main system	★★★★☆
Lighting	Low energy lighting in 33% of fixed outlets	★★★☆☆

Current primary energy use per square metre of floor area: 181 kWh/m² per year

The assessment does not take into consideration the physical condition of any element. 'Assumed' means that the insulation could not be inspected and an assumption has been made in the methodology based on age and type of construction.

Low and zero carbon energy sources

Low and zero carbon energy sources are sources of energy that release either very little or no carbon dioxide into the atmosphere when they are used. Installing these sources may help reduce energy bills as well as cutting carbon. There are none provided for this home.

Your home's heat demand

For most homes, the vast majority of energy costs derive from heating the home. Where applicable, this table shows the energy that could be saved in this property by insulating the loft and walls, based on typical energy use (shown within brackets as it is a reduction in energy use).

Heat demand	Existing dwelling	Impact of loft insulation	Impact of cavity wall insulation	Impact of solid wall insulation
Space heating (kWh per year)	14,165	N/A	N/A	N/A
Water heating (kWh per year)	2,358			

You could receive Renewable Heat Incentive (RHI) payments and help reduce carbon emissions by replacing your existing heating system with one that generates renewable heat, subject to meeting minimum energy efficiency requirements. The estimated energy required for space and water heating will form the basis of the payments. For more information, search for the domestic RHI on the www.gov.uk website.

Recommendations

The measures below will improve the energy performance of your dwelling. The performance ratings after improvements listed below are cumulative; that is, they assume the improvements have been installed in the order that they appear in the table. Further information about the recommended measures and other simple actions you could take today to save money is available at www.gov.uk/energy-grants-calculator. Before installing measures, you should make sure you have secured the appropriate permissions, where necessary. Such permissions might include permission from your landlord (if you are a tenant) or approval under Building Regulations for certain types of work.

Recommended measures	Indicative cost	Typical savings per year	Rating after improvement
Low energy lighting for all fixed outlets	£100	£ 51	C73
Solar photovoltaic panels, 2.5 kWp	£5,000 - £8,000	£ 292	C80

Opportunity to benefit from a Green Deal on this property

Green Deal Finance allows you to pay for some of the cost of your improvements in instalments under a Green Deal Plan (note that this is a credit agreement, but with instalments being added to the electricity bill for the property). The availability of a Green Deal Plan will depend upon your financial circumstances. There is a limit to how much Green Deal Finance can be used, which is determined by how much energy the improvements are estimated to **save** for a 'typical household'.

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Assessor's accreditation number:	EES/006272
Assessor's name:	Mr. Toby Gledhill
Phone number:	01924 249970
E-mail address:	toby@w-y-p.co.uk
Related party disclosure:	No related party

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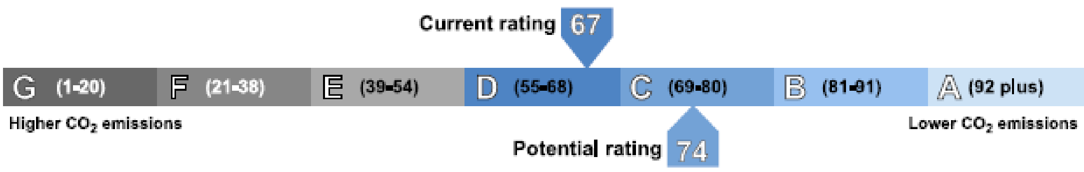
The average household causes about 6 tonnes of carbon dioxide every year. Based on this assessment, your home currently produces approximately 4.9 tonnes of carbon dioxide every year. Adopting the recommendations in this report can reduce emissions and protect the environment. If you were to install these recommendations you could reduce this amount by 1.1 tonnes per year. You could reduce emissions even more by switching to renewable energy sources.

The environmental impact rating is a measure of a home's impact on the environment in terms of carbon dioxide (CO_2) emissions based on standardised assumptions about occupancy and energy use. The higher the rating the less impact it has on the environment.



DEA 2, EPC Inputs, Test Property 2

RdSAP elmhurst energy

elmhurst energy systems

Summary Information

Surveyor:	C300-0001				
Name:	Toby Gledhill	**Title:** Mr.		**Tel Number:** 01904593570	
Survey Reference:	000308	**My Reference:**			
Current SAP rating:	C 72	**Potential SAP rating:**	C 80	**Emissions (t/year):**	4.874 tonnes
Current EI rating:	D 67	**Potential EI rating:**	C 74	**Fuel Bill:**	£1049

Property Details:

RdSAP version:	SAP 9.93
Reference Number:	C300-0001-000308
My Reference:	
Lodgement Required:	Yes
Regs Region:	England
EPC Language:	English
UPRN:	9494173578
Postcode:	YO30 6BX
Region:	North East England
House Name:	
House No:	11
Street:	Grosvenor Park
Locality:	
Town:	YORK
County:	
Property Tenure:	Owner-occupied
Transaction Type:	None of the above
Inspection Date:	09/03/2019
Process date:	11/03/2019

RdSAP Inputs

Property Description:

1.0 Property type:		H House
		M Mid-Terrace
2.0 Number of	**Storeys:**	3
	Habitable Rooms:	5
	Heated Habitable Rooms:	5
3.0 Date Built:	**Main Property**	I 1996-2002
	1st Extension	I 1996-2002

4.0 Dimensions:

Dimension type: **Internal**

Main Property	**Floor Area [m2]**	**Room Height [m]**	**Heat Loss Wall Perimeter [m]**	**Party Wall Length [m]**
2nd Floor:	54.00	2.60	10.80	20.00
1st Floor:	38.05	2.60	7.90	14.50
Lowest Floor:	38.05	2.60	21.70	14.50
1st Extension				
2nd Floor:	0.00	0.00	0.00	0.00
1st Floor:	0.00	0.00	0.00	0.00
Lowest Floor:	15.95	2.60	2.90	5.50

5.0 Conservatory:

Is there a conservatory?	Yes
Is it thermally separated?	No
Floor Area [m2]	6.75
Double Glazed	Yes
Glazed Perimeter [m]	7.90
Room Height	1.5 Storey

RdSAP elmhurst energy systems

Summary Information

7.0 Walls:

Main Property

Type	TI Timber Frame
Insulation	A As Built
Wall Thickness Unknown	No
Wall Thickness [mm]	310
U-value Known	No
Party Wall Type	S Solid masonry / timber / system build

1st Extension

As Main Wall	Yes
Type	TI Timber Frame
Insulation	A As Built
Wall Thickness Unknown	No
Wall Thickness [mm]	310
U-value Known	No
Party Wall Type	S Solid masonry / timber / system build

8.0 Roofs:

Main Property

Type	PA Pitched (slates/tiles), access to loft
Insulation	J Joists
Insulation Thickness	250 mm
U-value Known	No

1st Extension

As Main	No
Type	S Same dwelling above

9.0 Floors:

Main Property

Location	G Ground floor
Type	S Solid
Insulation	A As built
U-value Known	No

1st Extension

As Main	No
Location	U Above unheated space
Type	T Suspended timber
Insulation	A As built
U-value Known	No

10.0 Doors:

Total Number of Doors	1
Number of Insulated Doors	0

11.0 Windows:

Glazed Area	T Typical
Proportion Double\Triple-glazed	100 %
Glazing	Double pre 2002
Frame Type	Non-PVC frame
Draught Proofing	100 %

12.0 Ventilation & Cooling

No. of open Fireplaces	0
Mechanical Ventilation	No
Fixed Space Cooling	No

13.0 Lighting

Total number of light fittings	30
Total number of L.E.L. fittings	10

RdSAP

elmhurst energy systems

Summary Information

14.0 Main Heating1

PCDF boiler Reference	8140 Powermax, 155x, 82.00%
Main Heating Code	CGB CPSU with auto ign.
Heat Emitter	Radiators
Heat pump age	Unknown
Fuel Type	Mains gas
Flue Type	Balanced
Fan Assisted Flue	Yes
PCDF Heating Controls	0
Main Heating Controls	CBE Programmer, room thermostat and TRVs
PCDF Compensator	0
Percentage of Heat	100 %

14.1 Main Heating2

PCDF boiler Reference	0
Main Heating Code	
Percentage of Heat	0 %

15.0 Water Heating

Water Heating Code	HWP From the primary heating system

15.1 Hot Water Cylinder

Hot Water Cylinder Present	Yes

16.0 Solar water heating

Solar Water Heating	No

17.0 Waste Water Heat Recovery System

Total Number of rooms with bath and/or shower	2
Number of rooms with mixer shower and no bath	1
Number of rooms with bath and mixer shower	1
Is WWHRS present in the property?	No / Unknown

18.0 Flue Gas Heat Recovery System

Present	No

19.0 Photovoltaic Panel

Photovoltaic Panel	None

20.0 Wind Turbine

Terrain Type	Suburban
Wind turbine present?	No

21.0 Other Details

Electricity meter type	Single
Main gas	Yes

DEA 3 EPC, Test Property 2

Energy Performance Certificate

HM Government

11, Grosvenor Park, YORK, YO30 6BX

Dwelling type:	Mid-terrace house	**Reference number:**	0678-9041-7297-5231-7940
Date of assessment:	03 March 2019	**Type of assessment:**	RdSAP, existing dwelling
Date of certificate:	31 March 2019	**Total floor area:**	143 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

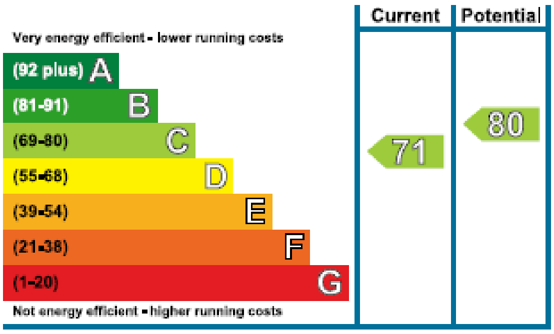
Estimated energy costs of dwelling for 3 years:	**£ 3,045**
Over 3 years you could save	**£ 180**

Estimated energy costs of this home

	Current costs	Potential costs	Potential future savings
Lighting	£ 345 over 3 years	£ 252 over 3 years	You could save £ 180 over 3 years
Heating	£ 2,361 over 3 years	£ 2,373 over 3 years	
Hot Water	£ 339 over 3 years	£ 240 over 3 years	
Totals	**£ 3,045**	**£ 2,865**	

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.

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

Recommended measures	Indicative cost	Typical savings over 3 years
1 Low energy lighting for all fixed outlets	£30	£ 81
2 Solar water heating	£4,000 - £6,000	£ 99
3 Solar photovoltaic panels, 2.5 kWp	£5,000 - £8,000	£ 876

To find out more about the recommended measures and other actions you could take today to save money, visit www.gov.uk/energy-grants-calculator or call **0300 123 1234** (standard national rate). The Green Deal may enable you to

Summary of this home's energy performance related features

Element	Description	Energy Efficiency
Walls	Cavity wall, as built, insulated (assumed)	★★★★☆
Roof	Pitched, 200 mm loft insulation	★★★★☆
Floor	Solid, limited insulation (assumed)	—
	To unheated space, limited insulation (assumed)	—
Windows	Fully double glazed	★★★☆☆
Main heating	Boiler and radiators, mains gas	★★★★☆
Main heating controls	Programmer, room thermostat and TRVs	★★★★☆
Secondary heating	None	—
Hot water	From main system	★★★★☆
Lighting	Low energy lighting in 63% of fixed outlets	★★★★☆

Current primary energy use per square metre of floor area: 189 kWh/m² per year

The assessment does not take into consideration the physical condition of any element. 'Assumed' means that the insulation could not be inspected and an assumption has been made in the methodology based on age and type of construction.

Low and zero carbon energy sources

Low and zero carbon energy sources are sources of energy that release either very little or no carbon dioxide into the atmosphere when they are used. Installing these sources may help reduce energy bills as well as cutting carbon. There are none provided for this home.

Your home's heat demand

For most homes, the vast majority of energy costs derive from heating the home. Where applicable, this table shows the energy that could be saved in this property by insulating the loft and walls, based on typical energy use (shown within brackets as it is a reduction in energy use).

Heat demand	Existing dwelling	Impact of loft insulation	Impact of cavity wall insulation	Impact of solid wall insulation
Space heating (kWh per year)	14,064	N/A	N/A	N/A
Water heating (kWh per year)	2,352			

You could receive Renewable Heat Incentive (RHI) payments and help reduce carbon emissions by replacing your existing heating system with one that generates renewable heat, subject to meeting minimum energy efficiency requirements. The estimated energy required for space and water heating will form the basis of the payments. For more information, search for the domestic RHI on the www.gov.uk website.

Recommendations

The measures below will improve the energy performance of your dwelling. The performance ratings after improvements listed below are cumulative; that is, they assume the improvements have been installed in the order that they appear in the table. Further information about the recommended measures and other simple actions you could take today to save money is available at www.gov.uk/energy-grants-calculator. Before installing measures, you should make sure you have secured the appropriate permissions, where necessary. Such permissions might include permission from your landlord (if you are a tenant) or approval under Building Regulations for certain types of work.

Recommended measures	Indicative cost	Typical savings per year	Rating after improvement
Low energy lighting for all fixed outlets	£30	£ 27	C72
Solar water heating	£4,000 - £6,000	£ 33	C73
Solar photovoltaic panels, 2.5 kWp	£5,000 - £8,000	£ 292	C80

Opportunity to benefit from a Green Deal on this property

Green Deal Finance allows you to pay for some of the cost of your improvements in instalments under a Green Deal Plan (note that this is a credit agreement, but with instalments being added to the electricity bill for the property). The availability of a Green Deal Plan will depend upon your financial circumstances. There is a limit to how much Green Deal Finance can be used, which is determined by how much energy the improvements are estimated to **save** for a 'typical household'.

You may be able to obtain support towards repairs or replacements of heating systems and/or basic insulation measures, if you are in receipt of qualifying benefits or tax credits. To learn more about this scheme and the rules about eligibility, call the Energy Saving Advice Service on **0300 123 1234** for England and Wales.

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This certificate and other data about the building may be shared with other bodies (including government departments and enforcement agencies) for research, statistical and enforcement purposes. Any personal data it contains will be processed in accordance with the General Data Protection Regulation and all applicable laws and regulations relating to the processing of personal data and privacy. For further information about this and how data about the property are used, please visit www.epcregister.com. To opt out of having information about your building made publicly available, please visit www.epcregister.com/optout.

Assessor's accreditation number:	EES/006272
Assessor's name:	Mr. Toby Gledhill
Phone number:	01924 249970
E-mail address:	toby@w-y-p.co.uk
Related party disclosure:	No related party

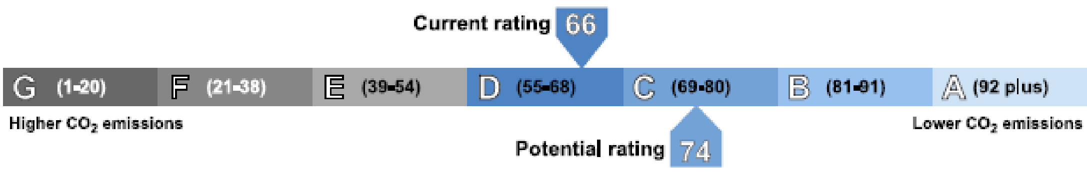
There is more information in the guidance document *Energy Performance Certificates for the marketing, sale and let of dwellings* available on the Government website at: www.gov.uk/government/collections/energy-performance-certificates. It explains the content and use of this document, advises on how to identify the authenticity of a certificate and how to make a complaint.

About the impact of buildings on the environment

One of the biggest contributors to global warming is carbon dioxide. The energy we use for heating, lighting and power in homes produces over a quarter of the UK's carbon dioxide emissions.

The average household causes about 6 tonnes of carbon dioxide every year. Based on this assessment, your home currently produces approximately 4.8 tonnes of carbon dioxide every year. Adopting the recommendations in this report can reduce emissions and protect the environment. If you were to install these recommendations you could reduce this amount by 1.2 tonnes per year. You could reduce emissions even more by switching to renewable energy sources.

The environmental impact rating is a measure of a home's impact on the environment in terms of carbon dioxide (CO_2) emissions based on standardised assumptions about occupancy and energy use. The higher the rating the less impact it has on the environment.



DEA 3, EPC Inputs, Test Property 2

RdSAP — elmhurst energy systems

Summary Information

Surveyor:	C300-0001				
Name:	Toby Gledhill	**Title:** Mr.		**Tel Number:** 01904593570	
Survey Reference:	000309	**My Reference:**			
Current SAP rating:	C 71	**Potential SAP rating:**	C 80	**Emissions (t/year):**	4.756 tonnes
Current EI rating:	D 66	**Potential EI rating:**	C 74	**Fuel Bill:**	£1015

Property Details:

RdSAP version:	SAP 9.93
Reference Number:	C300-0001-000309
My Reference:	
Lodgement Required:	Yes
Regs Region:	England
EPC Language:	English
UPRN:	9494173578
Postcode:	YO30 6BX
Region:	North East England
House Name:	
House No:	11
Street:	Grosvenor Park
Locality:	
Town:	YORK
County:	
Property Tenure:	Owner-occupied
Transaction Type:	None of the above
Inspection Date:	03/03/2019
Process date:	31/03/2019

RdSAP Inputs

Property Description:

1.0 Property type:		H House M Mid-Terrace
2.0 Number of	**Storeys:**	3
	Habitable Rooms:	5
	Heated Habitable Rooms:	5
3.0 Date Built:	**Main Property**	I 1996-2002
	1st Extension	I 1996-2002

4.0 Dimensions:

Dimension type: Internal

Main Property	**Floor Area [m2]**	**Room Height [m]**	**Heat Loss Wall Perimeter [m]**	**Party Wall Length [m]**
2nd Floor:	50.70	2.70	10.06	20.16
1st Floor:	35.74	2.45	7.27	14.70
Lowest Floor:	35.74	2.45	15.92	14.70
1st Extension				
2nd Floor:	0.00	0.00	0.00	0.00
1st Floor:	0.00	0.00	0.00	0.00
Lowest Floor:	14.96	2.45	2.74	5.46

5.0 Conservatory:

Is there a conservatory?	Yes
Is it thermally separated?	No
Floor Area [m2]	5.99
Double Glazed	Yes
Glazed Perimeter [m]	7.24
Room Height	1 Storey

RdSAP

elmhurst energy systems

Summary Information

7.0 Walls:

Main Property

Type	CA Cavity
Insulation	A As Built
Wall Thickness Unknown	No
Wall Thickness [mm]	300
U-value Known	No
Party Wall Type	U Unable to determine

1st Extension

As Main Wall	Yes
Type	CA Cavity
Insulation	A As Built
Wall Thickness Unknown	No
Wall Thickness [mm]	300
U-value Known	No
Party Wall Type	U Unable to determine

8.0 Roofs:

Main Property

Type	PA Pitched (slates/tiles), access to loft
Insulation	J Joists
Insulation Thickness	200 mm
U-value Known	No

1st Extension

As Main	No
Type	S Same dwelling above

9.0 Floors:

Main Property

Location	G Ground floor
Type	S Solid
Insulation	A As built
U-value Known	No

1st Extension

As Main	No
Location	U Above unheated space
Type	T Suspended timber
Insulation	A As built
U-value Known	No

10.0 Doors:

Total Number of Doors	2
Number of Insulated Doors	0

11.0 Windows:

Glazed Area	T Typical
Proportion Double\Triple-glazed	100 %
Glazing	Double pre 2002
Frame Type	Non-PVC frame
Draught Proofing	100 %

12.0 Ventilation & Cooling

No. of open Fireplaces	0
Mechanical Ventilation	No
Fixed Space Cooling	No

13.0 Lighting

Total number of light fittings	16
Total number of L.E.L. fittings	10

RdSAP

elmhurst energy systems

Summary Information

14.0 Main Heating1

PCDF boiler Reference	8140 Powermax, 155x, 82.00%
Main Heating Code	CGB CPSU with auto ign.
Heat Emitter	Radiators
Heat pump age	Unknown
Fuel Type	Mains gas
Flue Type	Balanced
Fan Assisted Flue	Yes
PCDF Heating Controls	0
Main Heating Controls	CBE Programmer, room thermostat and TRVs
PCDF Compensator	0
Percentage of Heat	100 %

14.1 Main Heating2

PCDF boiler Reference	0
Main Heating Code	
Percentage of Heat	0 %

15.0 Water Heating

Water Heating Code	HWP From the primary heating system

15.1 Hot Water Cylinder

Hot Water Cylinder Present	Yes

16.0 Solar water heating

Solar Water Heating	No

17.0 Waste Water Heat Recovery System

Total Number of rooms with bath and/or shower	2
Number of rooms with mixer shower and no bath	1
Number of rooms with bath and mixer shower	1
Is WWHRS present in the property?	No / Unknown

18.0 Flue Gas Heat Recovery System

Present	No

19.0 Photovoltaic Panel

Photovoltaic Panel	None

20.0 Wind Turbine

Terrain Type	Suburban
Wind turbine present?	No

21.0 Other Details

Electricity meter type	Single
Main gas	Yes

DEA 4 EPC, Test Property 2

Energy Performance Certificate

HM Government

11, Grosvenor Park, YORK, YO30 6BX

Dwelling type:	Mid-terrace house	**Reference number:**	8691-7725-5490-4358-1902
Date of assessment:	08 May 2019	**Type of assessment:**	RdSAP, existing dwelling
Date of certificate:	17 May 2019	**Total floor area:**	167 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:	**£ 3,504**
Over 3 years you could save	**£ 285**

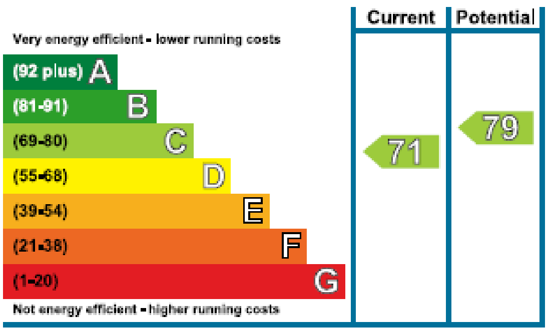
Estimated energy costs of this home

	Current costs	Potential costs	Potential future savings
Lighting	£ 453 over 3 years	£ 270 over 3 years	
Heating	£ 2,709 over 3 years	£ 2,517 over 3 years	
Hot Water	£ 342 over 3 years	£ 432 over 3 years	
Totals	**£ 3,504**	**£ 3,219**	

You could save £ 285 over 3 years

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.

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

Recommended measures	Indicative cost	Typical savings over 3 years
1 Low energy lighting for all fixed outlets	£50	£ 159
2 Replace heating unit with condensing unit	£2,200 - £3,000	£ 120
3 Solar photovoltaic panels, 2.5 kWp	£3,500 - £5,500	£ 876

To find out more about the recommended measures and other actions you could take today to save money, visit www.gov.uk/energy-grants-calculator or call **0300 123 1234** (standard national rate). The Green Deal may enable you to make your home warmer and cheaper to run

Summary of this home's energy performance related features

Element	Description	Energy Efficiency
Walls	Cavity wall, as built, insulated (assumed)	★★★★☆
Roof	Pitched, 200 mm loft insulation	★★★★☆
Floor	Solid, limited insulation (assumed)	—
Windows	Fully double glazed	★★★☆☆
Main heating	Boiler and radiators, mains gas	★★★★☆
Main heating controls	Programmer, room thermostat and TRVs	★★★★☆
Secondary heating	None	—
Hot water	From main system	★★★★☆
Lighting	Low energy lighting in 33% of fixed outlets	★★★☆☆

Current primary energy use per square metre of floor area: 187 kWh/m² per year

The assessment does not take into consideration the physical condition of any element. 'Assumed' means that the insulation could not be inspected and an assumption has been made in the methodology based on age and type of construction.

Low and zero carbon energy sources

Low and zero carbon energy sources are sources of energy that release either very little or no carbon dioxide into the atmosphere when they are used. Installing these sources may help reduce energy bills as well as cutting carbon. There are none provided for this home.

Your home's heat demand

For most homes, the vast majority of energy costs derive from heating the home. Where applicable, this table shows the energy that could be saved in this property by insulating the loft and walls, based on typical energy use (shown within brackets as it is a reduction in energy use).

Heat demand	Existing dwelling	Impact of loft insulation	Impact of cavity wall insulation	Impact of solid wall insulation
Space heating (kWh per year)	16,495	N/A	N/A	N/A
Water heating (kWh per year)	2,366			

You could receive Renewable Heat Incentive (RHI) payments and help reduce carbon emissions by replacing your existing heating system with one that generates renewable heat, subject to meeting minimum energy efficiency requirements. The estimated energy required for space and water heating will form the basis of the payments. For more information, search for the domestic RHI on the www.gov.uk website.

Recommendations

The measures below will improve the energy performance of your dwelling. The performance ratings after improvements listed below are cumulative; that is, they assume the improvements have been installed in the order that they appear in the table. Further information about the recommended measures and other simple actions you could take today to save money is available at www.gov.uk/energy-grants-calculator. Before installing measures, you should make sure you have secured the appropriate permissions, where necessary. Such permissions might include permission from your landlord (if you are a tenant) or approval under Building Regulations for certain types of work.

Recommended measures	Indicative cost	Typical savings per year	Rating after improvement
Low energy lighting for all fixed outlets	£50	£ 53	C72
Replace heating unit with condensing unit	£2,200 - £3,000	£ 40	C73
Solar photovoltaic panels, 2.5 kWp	£3,500 - £5,500	£ 292	C79

Alternative measures

There are alternative measures below which you could also consider for your home.

- Micro CHP

Opportunity to benefit from a Green Deal on this property

Green Deal Finance allows you to pay for some of the cost of your improvements in instalments under a Green Deal Plan (note that this is a credit agreement, but with instalments being added to the electricity bill for the property). The availability of a Green Deal Plan will depend upon your financial circumstances. There is a limit to how much Green Deal Finance can be used, which is determined by how much energy the improvements are estimated to **save** for a 'typical household'.

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Assessor's accreditation number:	EES/006272
Assessor's name:	Mr. Toby Gledhill
Phone number:	01924 249970
E-mail address:	toby@w-y-p.co.uk
Related party disclosure:	No related party

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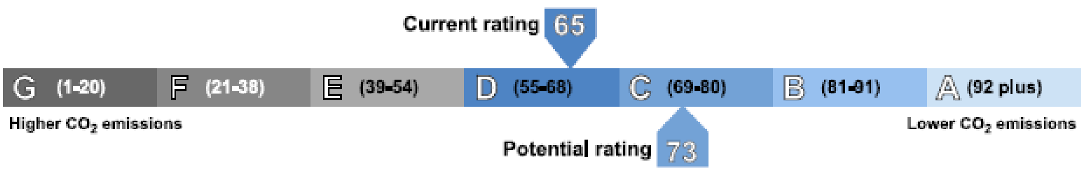
One of the biggest contributors to global warming is carbon dioxide. The energy we use for heating, lighting and power in homes produces over a quarter of the UK's carbon dioxide emissions.

The average household causes about 6 tonnes of carbon dioxide every year. Based on this assessment, your home currently produces approximately 5.5 tonnes of carbon dioxide every year. Adopting the recommendations in this report can reduce emissions and protect the environment. If you were to install these recommendations you could reduce this amount by 1.3 tonnes per year. You could reduce emissions even more by switching to renewable energy sources.

The environmental impact rating is a measure of a home's impact on the environment in terms of carbon dioxide (CO_2) emissions based on standardised assumptions about occupancy and energy use. The higher the rating the less impact it has on the environment.



DEA 4, EPC Inputs, Test Property 2

RdSAP elmhurst energy

elmhurst energy systems

Summary Information

Surveyor:	C300-0001				
Name:	Toby Gledhill		**Title:** Mr.	**Tel Number:** 01904593570	
Survey Reference:	000318		**My Reference:**		
Current SAP rating:	C 71	**Potential SAP rating:**	C 79	**Emissions (t/year):**	5.508 tonnes
Current EI rating:	D 65	**Potential EI rating:**	C 73	**Fuel Bill:**	£1167

Property Details:

RdSAP version:	SAP 9.93
Reference Number:	C300-0001-000318
My Reference:	
Lodgement Required:	Yes
Regs Region:	England
EPC Language:	English
UPRN:	9494173578
Postcode:	YO30 6BX
Region:	North East England
House Name:	
House No:	11
Street:	Grosvenor Park
Locality:	
Town:	YORK
County:	
Property Tenure:	Owner-occupied
Transaction Type:	None of the above
Inspection Date:	08/05/2019
Process date:	17/05/2019

RdSAP Inputs

Property Description:

1.0 Property type:		H House M Mid-Terrace
2.0 Number of	**Storeys:**	3
	Habitable Rooms:	6
	Heated Habitable Rooms:	6
3.0 Date Built	**Main Property**	I 1996-2002
	1st Extension	I 1996-2002

4.0 Dimensions:

Dimension type: Internal

Main Property

	Floor Area [m2]	Room Height [m]	Heat Loss Wall Perimeter [m]	Party Wall Length [m]
2nd Floor:	52.83	2.87	10.76	9.82
1st Floor:	33.63	2.56	7.74	9.82
Lowest Floor:	33.63	2.57	7.74	9.82
1st Extension				
2nd Floor:	0.00	0.00	0.00	0.00
1st Floor:	19.20	2.56	3.02	9.82
Lowest Floor:	19.20	2.57	3.02	9.82

5.0 Conservatory:

Is there a conservatory?	Yes
Is it thermally separated?	No
Floor Area [m2]	8.40
Double Glazed	Yes
Glazed Perimeter [m]	8.79
Room Height	1.5 Storey

RdSAP
elmhurst energy

elmhurst energy systems

Summary Information

7.0 Walls:

Main Property

Type	CA Cavity
Insulation	A As Built
Wall Thickness Unknown	No
Wall Thickness [mm]	320
U-value Known	No
Party Wall Type	U Unable to determine

1st Extension

As Main Wall	Yes
Type	CA Cavity
Insulation	A As Built
Wall Thickness Unknown	No
Wall Thickness [mm]	320
U-value Known	No
Party Wall Type	U Unable to determine

8.0 Roofs:

Main Property

Type	PA Pitched (slates/tiles), access to loft
Insulation	J Joists
Insulation Thickness	200 mm
U-value Known	No

1st Extension

As Main	No
Type	S Same dwelling above

9.0 Floors:

Main Property

Location	G Ground floor
Type	S Solid
Insulation	U Unknown
U-value Known	No

1st Extension

As Main	Yes
Location	G Ground floor
Type	S Solid
Insulation	U Unknown
U-value Known	No

10.0 Doors:

Total Number of Doors	2
Number of Insulated Doors	0

11.0 Windows:

Glazed Area	T Typical
Proportion Double\Triple-glazed	100 %
Glazing	Double with unknown install date
Frame Type	Non-PVC frame
Draught Proofing	100 %

12.0 Ventilation & Cooling

No. of open Fireplaces	0
Mechanical Ventilation	No
Fixed Space Cooling	No

13.0 Lighting

Total number of light fittings	15
Total number of L.E.L. fittings	5

RdSAP

elmhurst energy systems

Summary Information

14.0 Main Heating1

PCDF boiler Reference	8140 Powermax, 155x, 82.00%
Main Heating Code	CGB CPSU with auto ign.
Heat Emitter	Radiators
Heat pump age	Unknown
Fuel Type	Mains gas
Flue Type	Balanced
Fan Assisted Flue	Yes
PCDF Heating Controls	0
Main Heating Controls	CBE Programmer, room thermostat and TRVs
PCDF Compensator	0
Percentage of Heat	100 %

14.1 Main Heating2

PCDF boiler Reference	0
Main Heating Code	
Percentage of Heat	0 %

15.0 Water Heating

Water Heating Code	HWP From the primary heating system

15.1 Hot Water Cylinder

Hot Water Cylinder Present	Yes

16.0 Solar water heating

Solar Water Heating	No

17.0 Waste Water Heat Recovery System

Total Number of rooms with bath and/or shower	2
Number of rooms with mixer shower and no bath	1
Number of rooms with bath and mixer shower	0
Is WWHRS present in the property?	No / Unknown

18.0 Flue Gas Heat Recovery System

Present	No

19.0 Photovoltaic Panel

Photovoltaic Panel	None

20.0 Wind Turbine

Terrain Type	Suburban
Wind turbine present?	No

21.0 Other Details

Electricity meter type	Single
Main gas	Yes

DEA 5 EPC, Test Property 2

Energy Performance Certificate

HM Government

11, Grosvenor Park, YORK, YO30 6BX

Dwelling type:	Mid-terrace house	**Reference number:**	8591-7725-5490-4338-1906
Date of assessment:	08 May 2019	**Type of assessment:**	RdSAP, existing dwelling
Date of certificate:	17 May 2019	**Total floor area:**	148 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

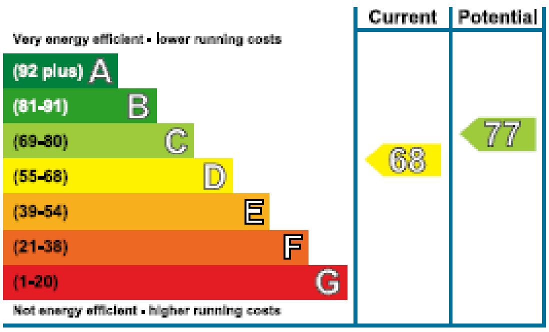
Estimated energy costs of dwelling for 3 years:	**£ 3,456**
Over 3 years you could save	**£ 210**

Estimated energy costs of this home

	Current costs	Potential costs	Potential future savings
Lighting	£ 378 over 3 years	£ 255 over 3 years	You could save £ 210 over 3 years
Heating	£ 2,751 over 3 years	£ 2,664 over 3 years	
Hot Water	£ 327 over 3 years	£ 327 over 3 years	
Totals	**£ 3,456**	**£ 3,246**	

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.

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

Recommended measures	Indicative cost	Typical savings over 3 years
1 Draught proofing	£80 - £120	£ 102
2 Low energy lighting for all fixed outlets	£55	£ 108
3 Solar photovoltaic panels, 2.5 kWp	£3,500 - £5,500	£ 876

To find out more about the recommended measures and other actions you could take today to save money, visit www.gov.uk/energy-grants-calculator or call **0300 123 1234** (standard national rate). The Green Deal may enable you to make your home warmer and cheaper to run.

Summary of this home's energy performance related features

Element	Description	Energy Efficiency
Walls	Timber frame, as built, insulated (assumed)	★★★★☆
Roof	Pitched, 200 mm loft insulation	★★★★☆
Floor	Solid, limited insulation (assumed)	—
	To unheated space, limited insulation (assumed)	—
Windows	Fully double glazed	★★★☆☆
Main heating	Boiler and radiators, mains gas	★★★★☆
Main heating controls	Programmer, room thermostat and TRVs	★★★★☆
Secondary heating	None	—
Hot water	From main system	★★★★☆
Lighting	Low energy lighting in 52% of fixed outlets	★★★★☆

Current primary energy use per square metre of floor area: 210 kWh/m² per year

The assessment does not take into consideration the physical condition of any element. 'Assumed' means that the insulation could not be inspected and an assumption has been made in the methodology based on age and type of construction.

Low and zero carbon energy sources

Low and zero carbon energy sources are sources of energy that release either very little or no carbon dioxide into the atmosphere when they are used. Installing these sources may help reduce energy bills as well as cutting carbon. There are none provided for this home.

Your home's heat demand

For most homes, the vast majority of energy costs derive from heating the home. Where applicable, this table shows the energy that could be saved in this property by insulating the loft and walls, based on typical energy use (shown within brackets as it is a reduction in energy use).

Heat demand	Existing dwelling	Impact of loft insulation	Impact of cavity wall insulation	Impact of solid wall insulation
Space heating (kWh per year)	16,809	N/A	N/A	N/A
Water heating (kWh per year)	2,267			

You could receive Renewable Heat Incentive (RHI) payments and help reduce carbon emissions by replacing your existing heating system with one that generates renewable heat, subject to meeting minimum energy efficiency requirements. The estimated energy required for space and water heating will form the basis of the payments. For more information, search for the domestic RHI on the www.gov.uk website.

Recommendations

The measures below will improve the energy performance of your dwelling. The performance ratings after improvements listed below are cumulative; that is, they assume the improvements have been installed in the order that they appear in the table. Further information about the recommended measures and other simple actions you could take today to save money is available at www.gov.uk/energy-grants-calculator. Before installing measures, you should make sure you have secured the appropriate permissions, where necessary. Such permissions might include permission from your landlord (if you are a tenant) or approval under Building Regulations for certain types of work.

Recommended measures	Indicative cost	Typical savings per year	Rating after improvement
Draught proofing	£80 - £120	£ 34	C69
Low energy lighting for all fixed outlets	£55	£ 36	C70
Solar photovoltaic panels, 2.5 kWp	£3,500 - £5,500	£ 292	C77

Opportunity to benefit from a Green Deal on this property

Green Deal Finance allows you to pay for some of the cost of your improvements in instalments under a Green Deal Plan (note that this is a credit agreement, but with instalments being added to the electricity bill for the property). The availability of a Green Deal Plan will depend upon your financial circumstances. There is a limit to how much Green Deal Finance can be used, which is determined by how much energy the improvements are estimated to **save** for a 'typical household'.

You may be able to obtain support towards repairs or replacements of heating systems and/or basic insulation measures, if you are in receipt of qualifying benefits or tax credits. To learn more about this scheme and the rules about eligibility, call the Energy Saving Advice Service on **0300 123 1234** for England and Wales.

About this document and the data in it

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This certificate and other data about the building may be shared with other bodies (including government departments and enforcement agencies) for research, statistical and enforcement purposes. Any personal data it contains will be processed in accordance with the General Data Protection Regulation and all applicable laws and regulations relating to the processing of personal data and privacy. For further information about this and how data about the property are used, please visit www.epcregister.com. To opt out of having information about your building made publicly available, please visit www.epcregister.com/optout.

Assessor's accreditation number: EES/006272
Assessor's name: Mr. Toby Gledhill
Phone number: 01924 249970
E-mail address: toby@w-y-p.co.uk
Related party disclosure: No related party

There is more information in the guidance document *Energy Performance Certificates for the marketing, sale and let of dwellings* available on the Government website at: www.gov.uk/government/collections/energy-performance-certificates. It explains the content and use of this document, advises on how to identify the authenticity of a certificate and how to make a complaint.

About the impact of buildings on the environment

One of the biggest contributors to global warming is carbon dioxide. The energy we use for heating, lighting and power in homes produces over a quarter of the UK's carbon dioxide emissions.

The average household causes about 6 tonnes of carbon dioxide every year. Based on this assessment, your home currently produces approximately 5.5 tonnes of carbon dioxide every year. Adopting the recommendations in this report can reduce emissions and protect the environment. If you were to install these recommendations you could reduce this amount by 1.2 tonnes per year. You could reduce emissions even more by switching to renewable energy sources.

The environmental impact rating is a measure of a home's impact on the environment in terms of carbon dioxide (CO_2) emissions based on standardised assumptions about occupancy and energy use. The higher the rating the less impact it has on the environment.

DEA 5, EPC Inputs, Test Property 2

RdSAP elmhurst energy systems

Summary Information

Surveyor:	C300-0001				
Name:	Toby Gledhill		**Title:** Mr.	**Tel Number:** 01904593570	
Survey Reference:	000317		**My Reference:**		
Current SAP rating:	D 68	**Potential SAP rating:**	C 77	**Emissions (t/year):**	5.482 tonnes
Current EI rating:	D 61	**Potential EI rating:**	C 70	**Fuel Bill:**	£1151

Property Details:

RdSAP version:	SAP 9.93
Reference Number:	C300-0001-000317
My Reference:	
Lodgement Required:	Yes
Regs Region:	England
EPC Language:	English
UPRN:	9494173578
Postcode:	YO30 6BX
Region:	North East England
House Name:	
House No:	11
Street:	Grosvenor Park
Locality:	
Town:	YORK
County:	
Property Tenure:	Owner-occupied
Transaction Type:	None of the above
Inspection Date:	08/05/2019
Process date:	17/05/2019

RdSAP Inputs

Property Description:

1.0 Property type:		H House
		M Mid-Terrace
2.0 Number of	**Storeys:**	3
	Habitable Rooms:	6
	Heated Habitable Rooms:	6
3.0 Date Built:	**Main Property**	I 1996-2002
	1st Extension	I 1996-2002

4.0 Dimensions:

Dimension type: Internal

Main Property

	Floor Area [m2]	Room Height [m]	Heat Loss Wall Perimeter [m]	Party Wall Length [m]
2nd Floor:	52.89	2.87	10.76	19.66
1st Floor:	33.59	2.57	7.73	13.29
Lowest Floor:	33.59	2.56	14.32	13.29
1st Extension				
2nd Floor:	0.00	0.00	0.00	0.00
1st Floor:	0.00	0.00	0.00	0.00
Lowest Floor:	19.30	2.57	3.03	6.37

5.0 Conservatory:

Is there a conservatory?	Yes
Is it thermally separated?	No
Floor Area [m2]	8.49
Double Glazed	No
Glazed Perimeter [m]	8.85
Room Height	1 Storey

RdSAP

elmhurst energy systems

Summary Information

7.0 Walls:

Main Property

Type	TI Timber Frame
Insulation	A As Built
Wall Thickness Unknown	No
Wall Thickness [mm]	320
U-value Known	No
Party Wall Type	U Unable to determine

1st Extension

As Main Wall	Yes
Type	TI Timber Frame
Insulation	A As Built
Wall Thickness Unknown	No
Wall Thickness [mm]	320
U-value Known	No
Party Wall Type	U Unable to determine

8.0 Roofs:

Main Property

Type	PA Pitched (slates/tiles), access to loft
Insulation	J Joists
Insulation Thickness	200 mm
U-value Known	No

1st Extension

As Main	No
Type	S Same dwelling above

9.0 Floors:

Main Property

Location	G Ground floor
Type	S Solid
Insulation	A As built
U-value Known	No

1st Extension

As Main	No
Location	U Above unheated space
Type	T Suspended timber
Insulation	A As built
U-value Known	No

10.0 Doors:

Total Number of Doors	1
Number of Insulated Doors	0

11.0 Windows:

Glazed Area	T Typical
Proportion Double\Triple-glazed	100 %
Glazing	Double pre 2002
Frame Type	Non-PVC frame
Draught Proofing	0 %

12.0 Ventilation & Cooling

No. of open Fireplaces	0
Mechanical Ventilation	No
Fixed Space Cooling	No

13.0 Lighting

Total number of light fittings	23
Total number of L.E.L. fittings	12

RdSAP elmhurst energy

elmhurst energy systems

Summary Information

14.0 Main Heating1

PCDF boiler Reference	1983 Powermax, 140, 82.10%
Main Heating Code	CGB CPSU with auto ign.
Heat Emitter	Radiators
Heat pump age	Unknown
Fuel Type	Mains gas
Flue Type	Balanced
Fan Assisted Flue	Yes
PCDF Heating Controls	0
Main Heating Controls	CBE Programmer, room thermostat and TRVs
PCDF Compensator	0
Percentage of Heat	100 %

14.1 Main Heating2

PCDF boiler Reference	0
Main Heating Code	
Percentage of Heat	0 %

15.0 Water Heating

Water Heating Code	HWP From the primary heating system

15.1 Hot Water Cylinder

Hot Water Cylinder Present	Yes

16.0 Solar water heating

Solar Water Heating	No

17.0 Waste Water Heat Recovery System

Total Number of rooms with bath and/or shower	2
Number of rooms with mixer shower and no bath	1
Number of rooms with bath and mixer shower	1
Is WWHRS present in the property?	No / Unknown

18.0 Flue Gas Heat Recovery System

Present	No

19.0 Photovoltaic Panel

Photovoltaic Panel	None

20.0 Wind Turbine

Terrain Type	Suburban
Wind turbine present?	No

21.0 Other Details

Electricity meter type	Single
Main gas	Yes

DEA 6 EPC, Test Property 2

Energy Performance Certificate

HM Government

11, Grosvenor Park, YORK, YO30 6BX

Dwelling type:	Mid-terrace house	**Reference number:**	2808-9041-7295-5031-7940
Date of assessment:	20 May 2019	**Type of assessment:**	RdSAP, existing dwelling
Date of certificate:	31 May 2019	**Total floor area:**	169 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

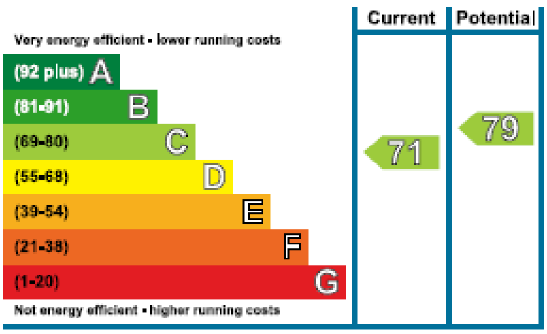
Estimated energy costs of dwelling for 3 years:	**£ 3,465**
Over 3 years you could save	**£ 189**

Estimated energy costs of this home

	Current costs	Potential costs	Potential future savings
Lighting	£ 345 over 3 years	£ 273 over 3 years	You could save £ 189 over 3 years
Heating	£ 2,778 over 3 years	£ 2,571 over 3 years	
Hot Water	£ 342 over 3 years	£ 432 over 3 years	
Totals	**£ 3,465**	**£ 3,276**	

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.

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

Recommended measures	Indicative cost	Typical savings over 3 years
1 Low energy lighting for all fixed outlets	£35	£ 66
2 Replace heating unit with condensing unit	£2,200 - £3,000	£ 126
3 Solar photovoltaic panels, 2.5 kWp	£3,500 - £5,500	£ 876

To receive advice on what measures you can take to reduce your energy bills, visit www.simpleenergyadvice.org.uk or call freephone **0800 444202**. The Green Deal may enable you to make your home warmer and cheaper to run.

Summary of this home's energy performance related features

Element	Description	Energy Efficiency
Walls	Cavity wall, as built, insulated (assumed)	★★★★☆
Roof	Pitched, 200 mm loft insulation	★★★★☆
Floor	Solid, limited insulation (assumed)	—
	To unheated space, limited insulation (assumed)	—
Windows	Fully double glazed	★★★☆☆
Main heating	Boiler and radiators, mains gas	★★★★☆
Main heating controls	Programmer, room thermostat and TRVs	★★★★☆
Secondary heating	None	—
Hot water	From main system	★★★★☆
Lighting	Low energy lighting in 73% of fixed outlets	★★★★★

Current primary energy use per square metre of floor area: 186 kWh/m² per year

The assessment does not take into consideration the physical condition of any element. 'Assumed' means that the insulation could not be inspected and an assumption has been made in the methodology based on age and type of construction.

Low and zero carbon energy sources

Low and zero carbon energy sources are sources of energy that release either very little or no carbon dioxide into the atmosphere when they are used. Installing these sources may help reduce energy bills as well as cutting carbon. There are none provided for this home.

Your home's heat demand

For most homes, the vast majority of energy costs derive from heating the home. Where applicable, this table shows the energy that could be saved in this property by insulating the loft and walls, based on typical energy use (shown within brackets as it is a reduction in energy use).

Heat demand	Existing dwelling	Impact of loft insulation	Impact of cavity wall insulation	Impact of solid wall insulation
Space heating (kWh per year)	16,987	N/A	N/A	N/A
Water heating (kWh per year)	2,367			

You could receive Renewable Heat Incentive (RHI) payments and help reduce carbon emissions by replacing your existing heating system with one that generates renewable heat, subject to meeting minimum energy efficiency requirements. The estimated energy required for space and water heating will form the basis of the payments. For more information, search for the domestic RHI on the www.gov.uk website.

Recommendations

The measures below will improve the energy performance of your dwelling. The performance ratings after improvements listed below are cumulative; that is, they assume the improvements have been installed in the order that they appear in the table. To receive advice on what measures you can take to reduce your energy bills, visit www.simpleenergyadvice.org.uk or call freephone 0800 444202. Before installing measures, you should make sure you have secured the appropriate permissions, where necessary. Such permissions might include permission from your landlord (if you are a tenant) or approval under Building Regulations for certain types of work.

Recommended measures	Indicative cost	Typical savings per year	Rating after improvement
Low energy lighting for all fixed outlets	£35	£ 22	C71
Replace heating unit with condensing unit	£2,200 - £3,000	£ 42	C72
Solar photovoltaic panels, 2.5 kWp	£3,500 - £5,500	£ 292	C79

Alternative measures

There are alternative measures below which you could also consider for your home.

- Micro CHP

Financial Support and the Green Deal

Green Deal Finance allows you to pay for some of the cost of your improvements in instalments under a Green Deal Plan (note that this is a credit agreement, but with instalments being added to the electricity bill for the property). The availability of a Green Deal Plan will depend upon your financial circumstances. There is a limit to how much Green Deal Finance can be used, which is determined by how much energy the improvements are estimated to **save** for a 'typical household'.

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Assessor's accreditation number:	EES/006272
Assessor's name:	Mr. Toby Gledhill
Phone number:	01924 249970
E-mail address:	toby@w-y-p.co.uk
Related party disclosure:	No related party

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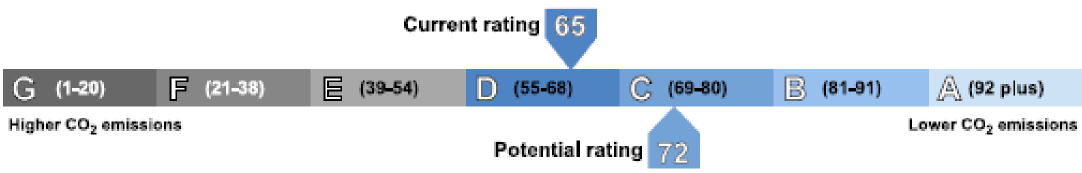
The average household causes about 6 tonnes of carbon dioxide every year. Based on this assessment, your home currently produces approximately 5.5 tonnes of carbon dioxide every year. Adopting the recommendations in this report can reduce emissions and protect the environment. If you were to install these recommendations you could reduce this amount by 1.2 tonnes per year. You could reduce emissions even more by switching to renewable energy sources.

The environmental impact rating is a measure of a home's impact on the environment in terms of carbon dioxide (CO_2) emissions based on standardised assumptions about occupancy and energy use. The higher the rating the less impact it has on the environment.



DEA 6, EPC Inputs, Test Property 2

RdSAP

elmhurst energy systems

Summary Information

Surveyor:	C300-0001				
Name:	Toby Gledhill	**Title:** Mr.		**Tel Number:** 01904593570	
Survey Reference:	000319	**My Reference:**			
Current SAP rating:	C 71	**Potential SAP rating:**	C 79	**Emissions (t/year):**	5.529 tonnes
Current EI rating:	D 65	**Potential EI rating:**	C 72	**Fuel Bill:**	£1155

Property Details:

RdSAP version:	SAP 9.93
Reference Number:	C300-0001-000319
My Reference:	
Lodgement Required:	Yes
Regs Region:	England
EPC Language:	English
UPRN:	9494173578
Postcode:	YO30 6BX
Region:	North East England
House Name:	
House No:	11
Street:	Grosvenor Park
Locality:	
Town:	YORK
County:	
Property Tenure:	Owner-occupied
Transaction Type:	None of the above
Inspection Date:	20/05/2019
Process date:	31/05/2019

RdSAP Inputs

Property Description:

1.0 Property type:		H House
		M Mid-Terrace
2.0 Number of	**Storeys:**	3
	Habitable Rooms:	6
	Heated Habitable Rooms:	6
3.0 Date Built:	**Main Property**	I 1996-2002
	1st Extension	I 1996-2002
	2nd Extension	I 1996-2002

4.0 Dimensions:

Dimension type: Internal

Main Property	**Floor Area [m2]**	**Room Height [m]**	**Heat Loss Wall Perimeter [m]**	**Party Wall Length [m]**
2nd Floor:	38.80	2.72	7.90	14.76
1st Floor:	38.80	2.56	7.90	14.76
Lowest Floor:	38.80	2.58	13.90	14.76
1st Extension				
2nd Floor:	0.00	0.00	0.00	0.00
1st Floor:	0.00	0.00	0.00	0.00
Lowest Floor:	15.12	2.58	2.80	5.40
2nd Extension				
2nd Floor:	0.00	0.00	0.00	0.00
1st Floor:	15.12	2.72	2.80	5.40
Lowest Floor:	15.12	2.56	2.80	5.40

5.0 Conservatory:

Is there a conservatory?	Yes
Is it thermally separated?	No
Floor Area [m2]	6.79
Double Glazed	Yes
Glazed Perimeter [m]	8.06
Room Height	1.5 Storey

RdSAP elmhurst energy

elmhurst energy systems

Summary Information

7.0 Walls:

Main Property

Type	CA Cavity
Insulation	A As Built
Wall Thickness Unknown	No
Wall Thickness [mm]	290
U-value Known	No
Party Wall Type	U Unable to determine

1st Extension

As Main Wall	Yes
Type	CA Cavity
Insulation	A As Built
Wall Thickness Unknown	No
Wall Thickness [mm]	290
U-value Known	No
Party Wall Type	U Unable to determine

2nd Extension

As Main Wall	Yes
Type	CA Cavity
Insulation	A As Built
Wall Thickness Unknown	No
Wall Thickness [mm]	290
U-value Known	No
Party Wall Type	U Unable to determine

8.0 Roofs:

Main Property

Type	PA Pitched (slates/tiles), access to loft
Insulation	J Joists
Insulation Thickness	200 mm
U-value Known	No

1st Extension

As Main	No
Type	S Same dwelling above

2nd Extension

As Main	Yes
Type	PA Pitched (slates/tiles), access to loft
Insulation	J Joists
Insulation Thickness	200 mm
U-value Known	No

9.0 Floors:

Main Property

Location	G Ground floor
Type	S Solid
Insulation	A As built
U-value Known	No

1st Extension

As Main	Yes
Location	G Ground floor
Type	S Solid
Insulation	A As built
U-value Known	No

2nd Extension

As Main	No
Location	U Above unheated space
Type	T Suspended timber
Insulation	A As built
U-value Known	No

RdSAP elmhurst energy

elmhurst energy systems

Summary Information

10.0 Doors:

Total Number of Doors	2
Number of Insulated Doors	0

11.0 Windows:

Glazed Area	T Typical
Proportion Double\Triple-glazed	100 %
Glazing	Double pre 2002
Frame Type	Non-PVC frame
Draught Proofing	100 %

12.0 Ventilation & Cooling

No. of open Fireplaces	0
Mechanical Ventilation	No
Fixed Space Cooling	No

13.0 Lighting

Total number of light fittings	26
Total number of L.E.L. fittings	19

14.0 Main Heating1

PCDF boiler Reference	8140 Powermax, 155x, 82.00%
Main Heating Code	CGB CPSU with auto ign.
Heat Emitter	Radiators
Heat pump age	Unknown
Fuel Type	Mains gas
Flue Type	Balanced
Fan Assisted Flue	Yes
PCDF Heating Controls	0
Main Heating Controls	CBE Programmer, room thermostat and TRVs
PCDF Compensator	0
Percentage of Heat	100 %

14.1 Main Heating2

PCDF boiler Reference	0
Main Heating Code	
Percentage of Heat	0 %

15.0 Water Heating

Water Heating Code	HWP From the primary heating system

15.1 Hot Water Cylinder

Hot Water Cylinder Present	Yes

16.0 Solar water heating

Solar Water Heating	No

17.0 Waste Water Heat Recovery System

Total Number of rooms with bath and/or shower	2
Number of rooms with mixer shower and no bath	1
Number of rooms with bath and mixer shower	0
Is WWHRS present in the property?	No / Unknown

18.0 Flue Gas Heat Recovery System

Present	No

19.0 Photovoltaic Panel

Photovoltaic Panel	None

20.0 Wind Turbine

Terrain Type	Suburban
Wind turbine present?	No

21.0 Other Details

Electricity meter type	Single
Main gas	Yes

DEA 7 EPC, Test Property 2

Energy Performance Certificate

HM Government

11, Grosvenor Park, YORK, YO30 6BX

Dwelling type:	Mid-terrace house	**Reference number:**	2708-9041-7295-5531-7944
Date of assessment:	20 May 2019	**Type of assessment:**	RdSAP, existing dwelling
Date of certificate:	06 June 2019	**Total floor area:**	149 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

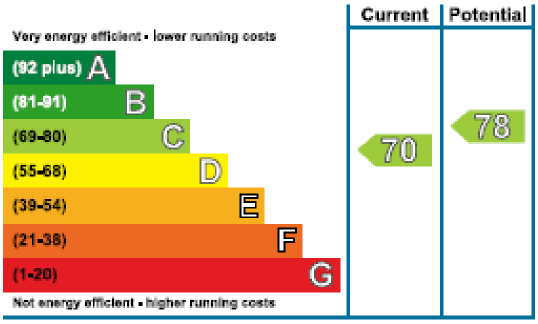
Estimated energy costs of dwelling for 3 years:	**£ 3,246**
Over 3 years you could save	**£ 174**

Estimated energy costs of this home

	Current costs	Potential costs	Potential future savings
Lighting	£ 453 over 3 years	£ 255 over 3 years	You could save £ 174 over 3 years
Heating	£ 2,454 over 3 years	£ 2,478 over 3 years	
Hot Water	£ 339 over 3 years	£ 339 over 3 years	
Totals	**£ 3,246**	**£ 3,072**	

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.

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

Recommended measures	Indicative cost	Typical savings over 3 years
1 Low energy lighting for all fixed outlets	£65	£ 174
2 Solar photovoltaic panels, 2.5 kWp	£3,500 - £5,500	£ 876

To receive advice on what measures you can take to reduce your energy bills, visit www.simpleenergyadvice.org.uk or call freephone **0800 444202**. The Green Deal may enable you to make your home warmer and cheaper to run.

Summary of this home's energy performance related features

Element	Description	Energy Efficiency
Walls	Timber frame, as built, insulated (assumed)	★★★★☆
Roof	Pitched, 200 mm loft insulation	★★★★☆
Floor	Solid, limited insulation (assumed)	—
	To unheated space, limited insulation (assumed)	—
Windows	Fully double glazed	★★★☆☆
Main heating	Boiler and radiators, mains gas	★★★★☆
Main heating controls	Programmer, room thermostat and TRVs	★★★★☆
Secondary heating	None	—
Hot water	From main system	★★★★☆
Lighting	Low energy lighting in 24% of fixed outlets	★★☆☆☆

Current primary energy use per square metre of floor area: 192 kWh/m² per year

The assessment does not take into consideration the physical condition of any element. 'Assumed' means that the insulation could not be inspected and an assumption has been made in the methodology based on age and type of construction.

Low and zero carbon energy sources

Low and zero carbon energy sources are sources of energy that release either very little or no carbon dioxide into the atmosphere when they are used. Installing these sources may help reduce energy bills as well as cutting carbon. There are none provided for this home.

Your home's heat demand

For most homes, the vast majority of energy costs derive from heating the home. Where applicable, this table shows the energy that could be saved in this property by insulating the loft and walls, based on typical energy use (shown within brackets as it is a reduction in energy use).

Heat demand	Existing dwelling	Impact of loft insulation	Impact of cavity wall insulation	Impact of solid wall insulation
Space heating (kWh per year)	14,730	N/A	N/A	N/A
Water heating (kWh per year)	2,356			

You could receive Renewable Heat Incentive (RHI) payments and help reduce carbon emissions by replacing your existing heating system with one that generates renewable heat, subject to meeting minimum energy efficiency requirements. The estimated energy required for space and water heating will form the basis of the payments. For more information, search for the domestic RHI on the www.gov.uk website.

Recommendations

The measures below will improve the energy performance of your dwelling. The performance ratings after improvements listed below are cumulative; that is, they assume the improvements have been installed in the order that they appear in the table. To receive advice on what measures you can take to reduce your energy bills, visit www.simpleenergyadvice.org.uk or call freephone 0800 444202. Before installing measures, you should make sure you have secured the appropriate permissions, where necessary. Such permissions might include permission from your landlord (if you are a tenant) or approval under Building Regulations for certain types of work.

Recommended measures	Indicative cost	Typical savings per year	Rating after improvement
Low energy lighting for all fixed outlets	£65	£ 58	C72
Solar photovoltaic panels, 2.5 kWp	£3,500 - £5,500	£ 292	C78

Financial Support and the Green Deal

Green Deal Finance allows you to pay for some of the cost of your improvements in instalments under a Green Deal Plan (note that this is a credit agreement, but with instalments being added to the electricity bill for the property). The availability of a Green Deal Plan will depend upon your financial circumstances. There is a limit to how much Green Deal Finance can be used, which is determined by how much energy the improvements are estimated to **save** for a 'typical household'.

You may also be able to obtain support towards repairs or replacements of heating systems and/or basic insulation measures under the ECO scheme, provided that you are in receipt of qualifying benefits or tax credits. To learn more about this scheme and the rules about eligibility, visit www.simpleenergyadvice.org.uk or call freephone **0800 444202** for England and Wales.

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This certificate and other data about the building may be shared with other bodies (including government departments and enforcement agencies) for research, statistical and enforcement purposes. Any personal data it contains will be processed in accordance with the General Data Protection Regulation and all applicable laws and regulations relating to the processing of personal data and privacy. For further information about this and how data about the property are used, please visit www.epcregister.com. To opt out of having information about your building made publicly available, please visit www.epcregister.com/optout.

Assessor's accreditation number:	EES/006272
Assessor's name:	Mr. Toby Gledhill
Phone number:	01924 249970
E-mail address:	toby@w-y-p.co.uk
Related party disclosure:	No related party

There is more information in the guidance document *Energy Performance Certificates for the marketing, sale and let of dwellings* available on the Government website at: www.gov.uk/government/collections/energy-performance-certificates. It explains the content and use of this document, advises on how to identify the authenticity of a certificate and how to make a complaint.

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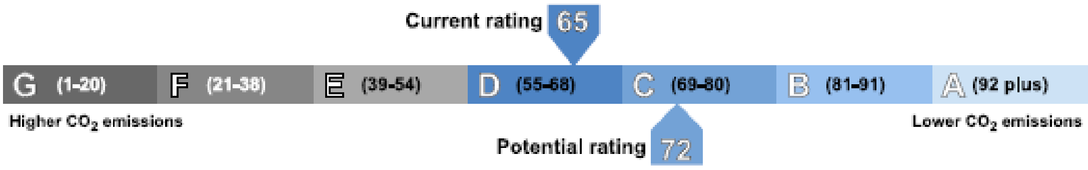
One of the biggest contributors to global warming is carbon dioxide. The energy we use for heating, lighting and power in homes produces over a quarter of the UK's carbon dioxide emissions.

The average household causes about 6 tonnes of carbon dioxide every year. Based on this assessment, your home currently produces approximately 5.0 tonnes of carbon dioxide every year. Adopting the recommendations in this report can reduce emissions and protect the environment. If you were to install these recommendations you could reduce this amount by 1.0 tonnes per year. You could reduce emissions even more by switching to renewable energy sources.

The environmental impact rating is a measure of a home's impact on the environment in terms of carbon dioxide (CO_2) emissions based on standardised assumptions about occupancy and energy use. The higher the rating the less impact it has on the environment.



DEA 7, EPC Inputs, Test Property 2

RdSAP elmhurst energy

elmhurst energy systems

Summary Information

Surveyor:	C300-0001				
Name:	Toby Gledhill	**Title:** Mr.		**Tel Number:** 01904593570	
Survey Reference:	000320	**My Reference:**			
Current SAP rating:	C 70	**Potential SAP rating:**	C 78	**Emissions (t/year):**	5.042 tonnes
Current EI rating:	D 65	**Potential EI rating:**	C 72	**Fuel Bill:**	£1082

Property Details:

RdSAP version:	SAP 9.93
Reference Number:	C300-0001-000320
My Reference:	
Lodgement Required:	Yes
Regs Region:	England
EPC Language:	English
UPRN:	9494173578
Postcode:	YO30 6BX
Region:	North East England
House Name:	
House No:	11
Street:	Grosvenor Park
Locality:	
Town:	YORK
County:	
Property Tenure:	Owner-occupied
Transaction Type:	None of the above
Inspection Date:	20/05/2019
Process date:	06/06/2019

RdSAP Inputs

Property Description:

1.0 Property type:		H House
		M Mid-Terrace
2.0 Number of	**Storeys:**	3
	Habitable Rooms:	5
	Heated Habitable Rooms:	5
3.0 Date Built:	**Main Property**	I 1996-2002
	1st Extension	I 1996-2002
	2nd Extension	I 1996-2002

4.0 Dimensions:

Dimension type: Internal

	Floor Area [m2]	Room Height [m]	Heat Loss Wall Perimeter [m]	Party Wall Length [m]
Main Property				
2nd Floor:	36.18	2.87	7.72	14.18
1st Floor:	36.18	2.56	7.72	14.18
Lowest Floor:	36.18	2.58	13.98	14.18
1st Extension				
2nd Floor:	0.00	0.00	0.00	0.00
1st Floor:	0.00	0.00	0.00	0.00
Lowest Floor:	17.10	2.56	3.00	5.70
2nd Extension				
2nd Floor:	0.00	0.00	0.00	0.00
1st Floor:	0.00	0.00	0.00	0.00
Lowest Floor:	17.10	2.87	3.00	5.70

5.0 Conservatory:

Is there a conservatory?	Yes
Is it thermally separated?	No
Floor Area [m2]	6.56
Double Glazed	Yes
Glazed Perimeter [m]	7.82
Room Height	1.5 Storey

RdSAP elmhurst energy

elmhurst energy systems

Summary Information

7.0 Walls:

Main Property

Type	TI Timber Frame
Insulation	A As Built
Wall Thickness Unknown	No
Wall Thickness [mm]	280
U-value Known	No
Party Wall Type	U Unable to determine

1st Extension

As Main Wall	Yes
Type	TI Timber Frame
Insulation	A As Built
Wall Thickness Unknown	No
Wall Thickness [mm]	280
U-value Known	No
Party Wall Type	U Unable to determine

2nd Extension

As Main Wall	Yes
Type	TI Timber Frame
Insulation	A As Built
Wall Thickness Unknown	No
Wall Thickness [mm]	280
U-value Known	No
Party Wall Type	U Unable to determine

8.0 Roofs:

Main Property

Type	PA Pitched (slates/tiles), access to loft
Insulation	J Joists
Insulation Thickness	200 mm
U-value Known	No

1st Extension

As Main	No
Type	S Same dwelling above

2nd Extension

As Main	Yes
Type	PA Pitched (slates/tiles), access to loft
Insulation	J Joists
Insulation Thickness	200 mm
U-value Known	No

9.0 Floors:

Main Property

Location	G Ground floor
Type	S Solid
Insulation	A As built
U-value Known	No

1st Extension

As Main	No
Location	U Above unheated space
Type	T Suspended timber
Insulation	A As built
U-value Known	No

2nd Extension

As Main	No
Location	S Same dwelling below

RdSAP

elmhurst energy systems

Summary Information

10.0 Doors:

Total Number of Doors	1
Number of Insulated Doors	0

11.0 Windows:

Glazed Area	T Typical
Proportion Double\Triple-glazed	100 %
Glazing	Double pre 2002
Frame Type	Non-PVC frame
Draught Proofing	100 %

12.0 Ventilation & Cooling

No. of open Fireplaces	0
Mechanical Ventilation	No
Fixed Space Cooling	No

13.0 Lighting

Total number of light fittings	17
Total number of L.E.L. fittings	4

14.0 Main Heating1

PCDF boiler Reference	8140 Powermax, 155x, 82.00%
Main Heating Code	CGB CPSU with auto ign.
Heat Emitter	Radiators
Heat pump age	Unknown
Fuel Type	Mains gas
Flue Type	Balanced
Fan Assisted Flue	Yes
PCDF Heating Controls	0
Main Heating Controls	CBE Programmer, room thermostat and TRVs
PCDF Compensator	0
Percentage of Heat	100 %

14.1 Main Heating2

PCDF boiler Reference	0
Main Heating Code	
Percentage of Heat	0 %

15.0 Water Heating

Water Heating Code	HWP From the primary heating system

15.1 Hot Water Cylinder

Hot Water Cylinder Present	Yes

16.0 Solar water heating

Solar Water Heating	No

17.0 Waste Water Heat Recovery System

Total Number of rooms with bath and/or shower	2
Number of rooms with mixer shower and no bath	1
Number of rooms with bath and mixer shower	1
Is WWHRS present in the property?	No / Unknown

18.0 Flue Gas Heat Recovery System

Present	No

19.0 Photovoltaic Panel

Photovoltaic Panel	None

20.0 Wind Turbine

Terrain Type	Suburban
Wind turbine present?	No

21.0 Other Details

Electricity meter type	Single
Main gas	Yes

DEA 8 EPC, Test Property 2

Energy Performance Certificate

HM Government

11, Grosvenor Park, YORK, YO30 6BX

Dwelling type:	Mid-terrace house	**Reference number:**	8491-7726-5490-4322-1906
Date of assessment:	02 June 2019	**Type of assessment:**	RdSAP, existing dwelling
Date of certificate:	06 June 2019	**Total floor area:**	150 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

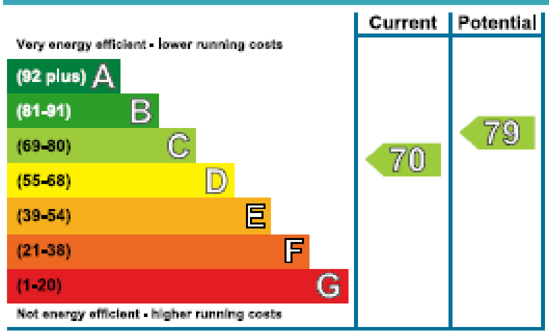
Estimated energy costs of dwelling for 3 years:	**£ 3,297**
Over 3 years you could save	**£ 246**

Estimated energy costs of this home

	Current costs	Potential costs	Potential future savings
Lighting	£ 414 over 3 years	£ 258 over 3 years	You could save £ 246 over 3 years
Heating	£ 2,544 over 3 years	£ 2,364 over 3 years	
Hot Water	£ 339 over 3 years	£ 429 over 3 years	
Totals	**£ 3,297**	**£ 3,051**	

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.

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

Recommended measures	Indicative cost	Typical savings over 3 years
1 Low energy lighting for all fixed outlets	£40	£ 138
2 Replace heating unit with condensing unit	£2,200 - £3,000	£ 111
3 Solar photovoltaic panels, 2.5 kWp	£3,500 - £5,500	£ 876

To receive advice on what measures you can take to reduce your energy bills, visit www.simpleenergyadvice.org.uk or call freephone **0800 444202**. The Green Deal may enable you to make your home warmer and cheaper to run.

Summary of this home's energy performance related features

Element	Description	Energy Efficiency
Walls	Timber frame, as built, insulated (assumed)	★★★★☆
Roof	Pitched, 250 mm loft insulation	★★★★☆
Floor	Solid, limited insulation (assumed)	—
	To unheated space, limited insulation (assumed)	—
Windows	Fully double glazed	★★★☆☆
Main heating	Boiler and radiators, mains gas	★★★★☆
Main heating controls	Programmer, room thermostat and TRVs	★★★★☆
Secondary heating	None	—
Hot water	From main system	★★★★☆
Lighting	Low energy lighting in 38% of fixed outlets	★★★☆☆

Current primary energy use per square metre of floor area: 195 kWh/m² per year

The assessment does not take into consideration the physical condition of any element. 'Assumed' means that the insulation could not be inspected and an assumption has been made in the methodology based on age and type of construction.

Low and zero carbon energy sources

Low and zero carbon energy sources are sources of energy that release either very little or no carbon dioxide into the atmosphere when they are used. Installing these sources may help reduce energy bills as well as cutting carbon. There are none provided for this home.

Your home's heat demand

For most homes, the vast majority of energy costs derive from heating the home. Where applicable, this table shows the energy that could be saved in this property by insulating the loft and walls, based on typical energy use (shown within brackets as it is a reduction in energy use).

Heat demand	Existing dwelling	Impact of loft insulation	Impact of cavity wall insulation	Impact of solid wall insulation
Space heating (kWh per year)	15,353	N/A	N/A	N/A
Water heating (kWh per year)	2,357			

You could receive Renewable Heat Incentive (RHI) payments and help reduce carbon emissions by replacing your existing heating system with one that generates renewable heat, subject to meeting minimum energy efficiency requirements. The estimated energy required for space and water heating will form the basis of the payments. For more information, search for the domestic RHI on the www.gov.uk website.

Recommendations

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Recommended measures	Indicative cost	Typical savings per year	Rating after improvement
Low energy lighting for all fixed outlets	£40	£ 46	C71
Replace heating unit with condensing unit	£2,200 - £3,000	£ 37	C72
Solar photovoltaic panels, 2.5 kWp	£3,500 - £5,500	£ 292	C79

Alternative measures

There are alternative measures below which you could also consider for your home.

- Micro CHP

Financial Support and the Green Deal

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Assessor's accreditation number:	EES/006272
Assessor's name:	Mr. Toby Gledhill
Phone number:	01924 249970
E-mail address:	toby@w-y-p.co.uk
Related party disclosure:	No related party

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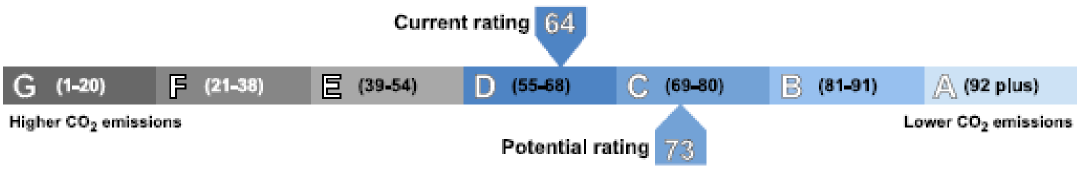


DEA 8, EPC Inputs, Test Property 2

RdSAP

elmhurst energy systems

Summary Information

Surveyor:	C300-0001				
Name:	Toby Gledhill	**Title:** Mr.		**Tel Number:** 01904593570	
Survey Reference:	000321	**My Reference:**			
Current SAP rating:	C 70	**Potential SAP rating:**	C 79	**Emissions (t/year):**	5.168 tonnes
Current EI rating:	D 64	**Potential EI rating:**	C 73	**Fuel Bill:**	£1100

Property Details:

RdSAP version:	SAP 9.93
Reference Number:	C300-0001-000321
My Reference:	
Lodgement Required:	Yes
Regs Region:	England
EPC Language:	English
UPRN:	9494173578
Postcode:	YO30 6BX
Region:	North East England
House Name:	
House No:	11
Street:	Grosvenor Park
Locality:	
Town:	YORK
County:	
Property Tenure:	Owner-occupied
Transaction Type:	None of the above
Inspection Date:	02/06/2019
Process date:	06/06/2019

RdSAP Inputs

Property Description:

1.0 Property type:		H House M Mid-Terrace
2.0 Number of	**Storeys:**	3
	Habitable Rooms:	4
	Heated Habitable Rooms:	4
3.0 Date Built:	**Main Property**	I 1996-2002
	1st Extension	I 1996-2002

4.0 Dimensions:

Dimension type: Internal

Main Property

	Floor Area [m2]	Room Height [m]	Heat Loss Wall Perimeter [m]	Party Wall Length [m]
2nd Floor:	37.10	2.88	16.25	14.38
1st Floor:	37.10	2.57	16.25	14.38
Lowest Floor:	37.10	2.59	13.80	14.38

1st Extension

	Floor Area [m2]	Room Height [m]	Heat Loss Wall Perimeter [m]	Party Wall Length [m]
2nd Floor:	0.00	0.00	0.00	0.00
1st Floor:	16.23	2.88	2.93	5.54
Lowest Floor:	16.23	2.57	2.93	5.54

5.0 Conservatory:

Is there a conservatory?	Yes
Is it thermally separated?	No
Floor Area [m2]	6.59
Double Glazed	Yes
Glazed Perimeter [m]	7.83
Room Height	1 Storey

RdSAP

elmhurst energy systems

Summary Information

7.0 Walls:

Main Property

Type	TI Timber Frame
Insulation	A As Built
Wall Thickness Unknown	No
Wall Thickness [mm]	300
U-value Known	No
Party Wall Type	U Unable to determine

1st Extension

As Main Wall	Yes
Type	TI Timber Frame
Insulation	A As Built
Wall Thickness Unknown	No
Wall Thickness [mm]	300
U-value Known	No
Party Wall Type	U Unable to determine

8.0 Roofs:

Main Property

Type	PA Pitched (slates/tiles), access to loft
Insulation	J Joists
Insulation Thickness	250 mm
U-value Known	No

1st Extension

As Main	Yes
Type	PA Pitched (slates/tiles), access to loft
Insulation	J Joists
Insulation Thickness	250 mm
U-value Known	No

9.0 Floors:

Main Property

Location	G Ground floor
Type	S Solid
Insulation	A As built
U-value Known	No

1st Extension

As Main	No
Location	U Above unheated space
Type	T Suspended timber
Insulation	A As built
U-value Known	No

10.0 Doors:

Total Number of Doors	2
Number of Insulated Doors	0

11.0 Windows:

Glazed Area	T Typical
Proportion Double\Triple-glazed	100 %
Glazing	Double pre 2002
Frame Type	Non-PVC frame
Draught Proofing	100 %

12.0 Ventilation & Cooling

No. of open Fireplaces	0
Mechanical Ventilation	No
Fixed Space Cooling	No

RdSAP elmhurst energy

elmhurst energy systems

Summary Information

13.0 Lighting

Total number of light fittings	13
Total number of L.E.L. fittings	5

14.0 Main Heating1

PCDF boiler Reference	8140 Powermax, 155x, 82.00%
Main Heating Code	CGB CPSU with auto ign.
Heat Emitter	Radiators
Heat pump age	Unknown
Fuel Type	Mains gas
Flue Type	Balanced
Fan Assisted Flue	Yes
PCDF Heating Controls	0
Main Heating Controls	CBE Programmer, room thermostat and TRVs
PCDF Compensator	0
Percentage of Heat	100 %

14.1 Main Heating2

PCDF boiler Reference	0
Main Heating Code	
Percentage of Heat	0 %

15.0 Water Heating

Water Heating Code	HWP From the primary heating system

15.1 Hot Water Cylinder

Hot Water Cylinder Present	Yes

16.0 Solar water heating

Solar Water Heating	No

17.0 Waste Water Heat Recovery System

Total Number of rooms with bath and/or shower	2
Number of rooms with mixer shower and no bath	1
Number of rooms with bath and mixer shower	1
Is WWHRS present in the property?	No / Unknown

18.0 Flue Gas Heat Recovery System

Present	No

19.0 Photovoltaic Panel

Photovoltaic Panel	None

20.0 Wind Turbine

Terrain Type	Suburban
Wind turbine present?	No

21.0 Other Details

Electricity meter type	Single
Main gas	Yes

DEA 9 EPC, Test Property 2

Energy Performance Certificate

HM Government

11, Grosvenor Park, YORK, YO30 6BX

Dwelling type:	Mid-terrace house	**Reference number:**	9598-9041-7296-5731-7940
Date of assessment:	11 June 2019	**Type of assessment:**	RdSAP, existing dwelling
Date of certificate:	11 June 2019	**Total floor area:**	152 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

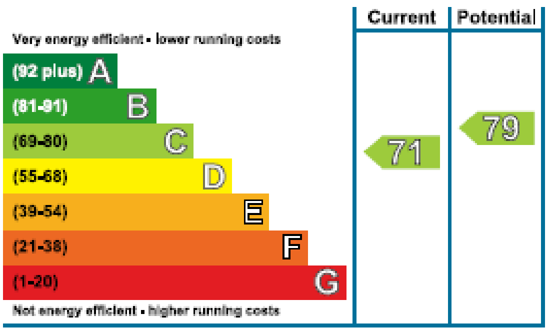
Estimated energy costs of dwelling for 3 years:	**£ 3,141**
Over 3 years you could save	**£ 126**

Estimated energy costs of this home

	Current costs	Potential costs	Potential future savings
Lighting	£ 402 over 3 years	£ 258 over 3 years	**You could save £ 126 over 3 years**
Heating	£ 2,400 over 3 years	£ 2,418 over 3 years	
Hot Water	£ 339 over 3 years	£ 339 over 3 years	
Totals	**£ 3,141**	**£ 3,015**	

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.

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

Recommended measures	Indicative cost	Typical savings over 3 years
1 Low energy lighting for all fixed outlets	£50	£ 126
2 Solar photovoltaic panels, 2.5 kWp	£3,500 - £5,500	£ 876

To receive advice on what measures you can take to reduce your energy bills, visit **www.simpleenergyadvice.org.uk** or call freephone **0800 444202**. The Green Deal may enable you to make your home warmer and cheaper to run.

Summary of this home's energy performance related features

Element	Description	Energy Efficiency
Walls	Timber frame, as built, insulated (assumed)	★★★★☆
Roof	Pitched, 200 mm loft insulation	★★★★☆
Floor	Solid, limited insulation (assumed)	—
	To unheated space, limited insulation (assumed)	—
Windows	Fully double glazed	★★★☆☆
Main heating	Boiler and radiators, mains gas	★★★★☆
Main heating controls	Programmer, room thermostat and TRVs	★★★★☆
Secondary heating	None	—
Hot water	From main system	★★★★☆
Lighting	Low energy lighting in 44% of fixed outlets	★★★☆☆

Current primary energy use per square metre of floor area: 183 kWh/m² per year

The assessment does not take into consideration the physical condition of any element. 'Assumed' means that the insulation could not be inspected and an assumption has been made in the methodology based on age and type of construction.

Low and zero carbon energy sources

Low and zero carbon energy sources are sources of energy that release either very little or no carbon dioxide into the atmosphere when they are used. Installing these sources may help reduce energy bills as well as cutting carbon. There are none provided for this home.

Your home's heat demand

For most homes, the vast majority of energy costs derive from heating the home. Where applicable, this table shows the energy that could be saved in this property by insulating the loft and walls, based on typical energy use (shown within brackets as it is a reduction in energy use).

Heat demand	Existing dwelling	Impact of loft insulation	Impact of cavity wall insulation	Impact of solid wall insulation
Space heating (kWh per year)	14,338	N/A	N/A	N/A
Water heating (kWh per year)	2,358			

You could receive Renewable Heat Incentive (RHI) payments and help reduce carbon emissions by replacing your existing heating system with one that generates renewable heat, subject to meeting minimum energy efficiency requirements. The estimated energy required for space and water heating will form the basis of the payments. For more information, search for the domestic RHI on the www.gov.uk website.

Recommendations

The measures below will improve the energy performance of your dwelling. The performance ratings after improvements listed below are cumulative; that is, they assume the improvements have been installed in the order that they appear in the table. To receive advice on what measures you can take to reduce your energy bills, visit www.simpleenergyadvice.org.uk or call freephone 0800 444202. Before installing measures, you should make sure you have secured the appropriate permissions, where necessary. Such permissions might include permission from your landlord (if you are a tenant) or approval under Building Regulations for certain types of work.

Recommended measures	Indicative cost	Typical savings per year	Rating after improvement
Low energy lighting for all fixed outlets	£50	£ 42	C72
Solar photovoltaic panels, 2.5 kWp	£3,500 - £5,500	£ 292	C79

Financial Support and the Green Deal

Green Deal Finance allows you to pay for some of the cost of your improvements in instalments under a Green Deal Plan (note that this is a credit agreement, but with instalments being added to the electricity bill for the property). The availability of a Green Deal Plan will depend upon your financial circumstances. There is a limit to how much Green Deal Finance can be used, which is determined by how much energy the improvements are estimated to **save** for a 'typical household'.

You may also be able to obtain support towards repairs or replacements of heating systems and/or basic insulation measures under the ECO scheme, provided that you are in receipt of qualifying benefits or tax credits. To learn more about this scheme and the rules about eligibility, visit www.simpleenergyadvice.org.uk or call freephone **0800 444202** for England and Wales.

11, Grosvenor Park, , , YORK, YO30 6BX
11 June 2019 RRN: 9598-9041-7296-5731-7940

Energy Performance Certificate

About this document and the data in it

This document has been produced following an energy assessment undertaken by a qualified Energy Assessor, accredited by Elmhurst Energy Systems Ltd. You can obtain contact details of the Accreditation Scheme at www.elmhurstenergy.co.uk.

A copy of this certificate has been lodged on a national register as a requirement under the Energy Performance of Buildings Regulations 2012 as amended. It will be made available via the online search function at www.epcregister.com. The certificate (including the building address) and other data about the building collected during the energy assessment but not shown on the certificate, for instance heating system data, will be made publicly available at www.opendatacommunities.org.

This certificate and other data about the building may be shared with other bodies (including government departments and enforcement agencies) for research, statistical and enforcement purposes. Any personal data it contains will be processed in accordance with the General Data Protection Regulation and all applicable laws and regulations relating to the processing of personal data and privacy. For further information about this and how data about the property are used, please visit www.epcregister.com. To opt out of having information about your building made publicly available, please visit www.epcregister.com/optout.

Assessor's accreditation number:	EES/006272
Assessor's name:	Mr. Toby Gledhill
Phone number:	01924 249970
E-mail address:	toby@w-y-p.co.uk
Related party disclosure:	No related party

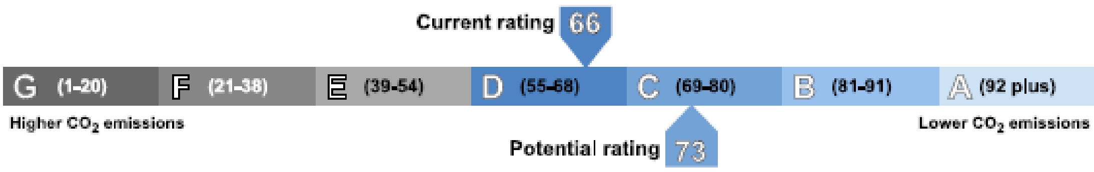
There is more information in the guidance document *Energy Performance Certificates for the marketing, sale and let of dwellings* available on the Government website at: www.gov.uk/government/collections/energy-performance-certificates. It explains the content and use of this document, advises on how to identify the authenticity of a certificate and how to make a complaint.

About the impact of buildings on the environment

One of the biggest contributors to global warming is carbon dioxide. The energy we use for heating, lighting and power in homes produces over a quarter of the UK's carbon dioxide emissions.

The average household causes about 6 tonnes of carbon dioxide every year. Based on this assessment, your home currently produces approximately 4.9 tonnes of carbon dioxide every year. Adopting the recommendations in this report can reduce emissions and protect the environment. If you were to install these recommendations you could reduce this amount by 1.0 tonnes per year. You could reduce emissions even more by switching to renewable energy sources.

The environmental impact rating is a measure of a home's impact on the environment in terms of carbon dioxide (CO_2) emissions based on standardised assumptions about occupancy and energy use. The higher the rating the less impact it has on the environment.



DEA 9, EPC Inputs, Test Property 2

RdSAP elmhurst energy

Summary Information

Surveyor:	A013-0001				
Name:	Helen Pirozek	**Title:** Ms.		**Tel Number:** 01904 761823	
Survey Reference:	003240	**My Reference:**			
Current SAP rating:	C 71	**Potential SAP rating:**	C 79	**Emissions (t/year):**	4.888 tonnes
Current EI rating:	D 66	**Potential EI rating:**	C 73	**Fuel Bill:**	£1047

Property Details:

RdSAP version:	SAP 9.93
Reference Number:	A013-0001-003240
My Reference:	
Lodgement Required:	Yes
Regs Region:	England
EPC Language:	English
UPRN:	9494173578
Postcode:	YO30 6BX
Region:	North East England
House Name:	
House No:	11
Street:	Grosvenor Park
Locality:	
Town:	YORK
County:	
Property Tenure:	Owner-occupied
Transaction Type:	None of the above
Inspection Date:	11/06/2019
Process date:	11/06/2019

RdSAP Inputs

Property Description:

1.0 Property type:		H House
		M Mid-Terrace
2.0 Number of	**Storeys:**	3
	Habitable Rooms:	5
	Heated Habitable Rooms:	5
3.0 Date Built:	**Main Property**	I 1996-2002
	1st Extension	I 1996-2002

4.0 Dimensions:

Dimension type: Internal

Main Property

	Floor Area [m2]	Room Height [m]	Heat Loss Wall Perimeter [m]	Party Wall Length [m]
2nd Floor:	36.89	2.90	7.90	14.40
1st Floor:	36.89	2.55	7.90	14.40
Lowest Floor:	36.89	2.60	13.50	14.40
1st Extension				
2nd Floor:	0.00	0.00	0.00	0.00
1st Floor:	16.24	2.90	2.90	5.60
Lowest Floor:	16.24	2.55	2.90	5.60

5.0 Conservatory:

Is there a conservatory?	Yes
Is it thermally separated?	No
Floor Area [m2]	8.41
Double Glazed	Yes
Glazed Perimeter [m]	5.80
Room Height	1.5 Storey

RdSAP

elmhurst energy systems

Summary Information

7.0 Walls:

Main Property

Type	TI Timber Frame
Insulation	A As Built
Wall Thickness Unknown	No
Wall Thickness [mm]	310
U-value Known	No
Party Wall Type	U Unable to determine

1st Extension

As Main Wall	Yes
Type	TI Timber Frame
Insulation	A As Built
Wall Thickness Unknown	No
Wall Thickness [mm]	310
U-value Known	No
Party Wall Type	U Unable to determine

8.0 Roofs:

Main Property

Type	PA Pitched (slates/tiles), access to loft
Insulation	J Joists
Insulation Thickness	200 mm
U-value Known	No

1st Extension

As Main	Yes
Type	PA Pitched (slates/tiles), access to loft
Insulation	J Joists
Insulation Thickness	200 mm
U-value Known	No

9.0 Floors:

Main Property

Location	G Ground floor
Type	S Solid
Insulation	A As built
U-value Known	No

1st Extension

As Main	No
Location	U Above unheated space
Type	U Unknown
Insulation	A As built
U-value Known	No

10.0 Doors:

Total Number of Doors	1
Number of Insulated Doors	0

11.0 Windows:

Glazed Area	T Typical
Proportion Double\Triple-glazed	100 %
Glazing	Double pre 2002
Frame Type	Non-PVC frame
Draught Proofing	100 %

12.0 Ventilation & Cooling

No. of open Fireplaces	0
Mechanical Ventilation	No
Fixed Space Cooling	No

Summary Information

13.0 Lighting

Total number of light fittings	18
Total number of L.E.L. fittings	8

14.0 Main Heating1

PCDF boiler Reference	8140 Powermax, 155x, 82.00%
Main Heating Code	CGB CPSU with auto ign.
Heat Emitter	Radiators
Heat pump age	Unknown
Fuel Type	Mains gas
Flue Type	Balanced
Fan Assisted Flue	Yes
PCDF Heating Controls	0
Main Heating Controls	CBE Programmer, room thermostat and TRVs
PCDF Compensator	0
Percentage of Heat	100 %

14.1 Main Heating2

PCDF boiler Reference	0
Main Heating Code	
Percentage of Heat	0 %

15.0 Water Heating

Water Heating Code	HWP From the primary heating system

15.1 Hot Water Cylinder

Hot Water Cylinder Present	Yes

16.0 Solar water heating

Solar Water Heating	No

17.0 Waste Water Heat Recovery System

Total Number of rooms with bath and/or shower	2
Number of rooms with mixer shower and no bath	1
Number of rooms with bath and mixer shower	1
Is WWHRS present in the property?	No / Unknown

18.0 Flue Gas Heat Recovery System

Present	No

19.0 Photovoltaic Panel

Photovoltaic Panel	None

20.0 Wind Turbine

Terrain Type	Suburban
Wind turbine present?	No

21.0 Other Details

Electricity meter type	Single
Main gas	Yes

DEA 10 EPC, Test Property 2

Energy Performance Certificate

HM Government

11, Grosvenor Park, YORK, YO30 6BX

Dwelling type:	Mid-terrace house	**Reference number:**	8191-7726-5490-4339-1996
Date of assessment:	11 June 2019	**Type of assessment:**	RdSAP, existing dwelling
Date of certificate:	14 June 2019	**Total floor area:**	151 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

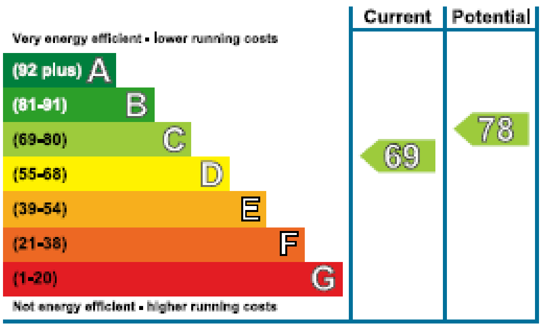
Estimated energy costs of dwelling for 3 years:	**£ 3,426**
Over 3 years you could save	**£ 309**

Estimated energy costs of this home

	Current costs	Potential costs	Potential future savings
Lighting	£ 417 over 3 years	£ 258 over 3 years	You could save £ 309 over 3 years
Heating	£ 2,670 over 3 years	£ 2,430 over 3 years	
Hot Water	£ 339 over 3 years	£ 429 over 3 years	
Totals	**£ 3,426**	**£ 3,117**	

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.

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

Recommended measures	Indicative cost	Typical savings over 3 years
1 Draught proofing	£80 - £120	£ 57
2 Low energy lighting for all fixed outlets	£40	£ 141
3 Replace heating unit with condensing unit	£2,200 - £3,000	£ 114

See page 3 for a full list of recommendations for this property.

To receive advice on what measures you can take to reduce your energy bills, visit www.simpleenergyadvice.org.uk or call freephone **0800 444202**. The Green Deal may enable you to make your home warmer and cheaper to run.

Summary of this home's energy performance related features

Element	Description	Energy Efficiency
Walls	Cavity wall, as built, insulated (assumed)	★★★★☆
Roof	Pitched, 250 mm loft insulation	★★★★☆
Floor	Solid, limited insulation (assumed)	—
	To unheated space, limited insulation (assumed)	—
Windows	Fully double glazed	★★★☆☆
Main heating	Boiler and radiators, mains gas	★★★★☆
Main heating controls	Programmer, room thermostat and TRVs	★★★★☆
Secondary heating	None	—
Hot water	From main system	★★★★☆
Lighting	Low energy lighting in 38% of fixed outlets	★★★☆☆

Current primary energy use per square metre of floor area: 203 kWh/m² per year

The assessment does not take into consideration the physical condition of any element. 'Assumed' means that the insulation could not be inspected and an assumption has been made in the methodology based on age and type of construction.

Low and zero carbon energy sources

Low and zero carbon energy sources are sources of energy that release either very little or no carbon dioxide into the atmosphere when they are used. Installing these sources may help reduce energy bills as well as cutting carbon. There are none provided for this home.

Your home's heat demand

For most homes, the vast majority of energy costs derive from heating the home. Where applicable, this table shows the energy that could be saved in this property by insulating the loft and walls, based on typical energy use (shown within brackets as it is a reduction in energy use).

Heat demand	Existing dwelling	Impact of loft insulation	Impact of cavity wall insulation	Impact of solid wall insulation
Space heating (kWh per year)	16,238	N/A	N/A	N/A
Water heating (kWh per year)	2,357			

You could receive Renewable Heat Incentive (RHI) payments and help reduce carbon emissions by replacing your existing heating system with one that generates renewable heat, subject to meeting minimum energy efficiency requirements. The estimated energy required for space and water heating will form the basis of the payments. For more information, search for the domestic RHI on the www.gov.uk website.

Recommendations

The measures below will improve the energy performance of your dwelling. The performance ratings after improvements listed below are cumulative; that is, they assume the improvements have been installed in the order that they appear in the table. To receive advice on what measures you can take to reduce your energy bills, visit www.simpleenergyadvice.org.uk or call freephone 0800 444202. Before installing measures, you should make sure you have secured the appropriate permissions, where necessary. Such permissions might include permission from your landlord (if you are a tenant) or approval under Building Regulations for certain types of work.

Recommended measures	Indicative cost	Typical savings per year	Rating after improvement
Draught proofing	£80 - £120	£ 19	C69
Low energy lighting for all fixed outlets	£40	£ 47	C70
Replace heating unit with condensing unit	£2,200 - £3,000	£ 38	C71
Solar photovoltaic panels, 2.5 kWp	£3,500 - £5,500	£ 292	C78

Alternative measures

There are alternative measures below which you could also consider for your home.

- Micro CHP

Financial Support and the Green Deal

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11, Grosvenor Park, , , YORK, YO30 6BX
14 June 2019 RRN: 8191-7726-5490-4339-1996

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Assessor's accreditation number:	EES/006272
Assessor's name:	Mr. Toby Gledhill
Phone number:	01924 249970
E-mail address:	toby@w-y-p.co.uk
Related party disclosure:	No related party

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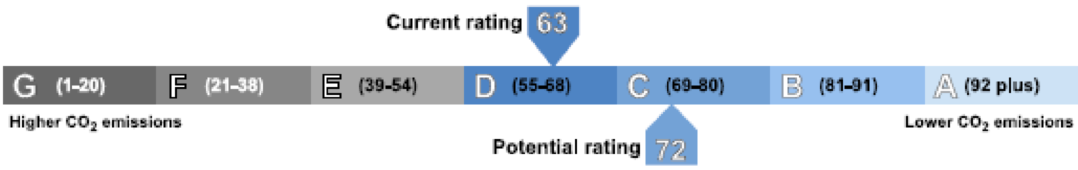
The average household causes about 6 tonnes of carbon dioxide every year. Based on this assessment, your home currently produces approximately 5.4 tonnes of carbon dioxide every year. Adopting the recommendations in this report can reduce emissions and protect the environment. If you were to install these recommendations you could reduce this amount by 1.3 tonnes per year. You could reduce emissions even more by switching to renewable energy sources.

The environmental impact rating is a measure of a home's impact on the environment in terms of carbon dioxide (CO_2) emissions based on standardised assumptions about occupancy and energy use. The higher the rating the less impact it has on the environment.



DEA 10, EPC Inputs, Test Property 2

RdSAP elmhurst energy

elmhurst energy systems

Summary Information

Surveyor:	L970-0001				
Name:	Nicola Chadwick	**Title:** Mrs.		**Tel Number:** 07841129947	
Survey Reference:	000313	**My Reference:**			
Current SAP rating:	C 69	**Potential SAP rating:**	C 78	**Emissions (t/year):**	5.401 tonnes
Current EI rating:	D 63	**Potential EI rating:**	C 72	**Fuel Bill:**	£1142

Property Details:

RdSAP version:	SAP 9.93
Reference Number:	L970-0001-000313
My Reference:	
Lodgement Required:	Yes
Regs Region:	England
EPC Language:	English
UPRN:	9494173578
Postcode:	YO30 6BX
Region:	North East England
House Name:	
House No:	11
Street:	Grosvenor Park
Locality:	
Town:	YORK
County:	
Property Tenure:	Owner-occupied
Transaction Type:	None of the above
Inspection Date:	12/06/2019
Process date:	13/06/2019

RdSAP Inputs

Property Description:

1.0 Property type:		H House M Mid-Terrace
2.0 Number of	**Storeys:**	3
	Habitable Rooms:	5
	Heated Habitable Rooms:	5
3.0 Date Built:	**Main Property**	I 1996-2002
	1st Extension	I 1996-2002

4.0 Dimensions:

Dimension type: Internal

Main Property

	Floor Area [m2]	Room Height [m]	Heat Loss Wall Perimeter [m]	Party Wall Length [m]
2nd Floor:	37.07	2.86	7.87	14.20
1st Floor:	37.07	2.54	7.87	14.20
Lowest Floor:	37.07	2.57	21.86	14.20
1st Extension				
2nd Floor:	0.00	0.00	0.00	0.00
1st Floor:	16.42	2.86	2.85	5.76
Lowest Floor:	16.42	2.54	2.85	5.76

5.0 Conservatory:

Is there a conservatory?	Yes
Is it thermally separated?	No
Floor Area [m2]	6.56
Double Glazed	Yes
Glazed Perimeter [m]	7.82
Room Height	1.5 Storey

RdSAP elmhurst energy systems

Summary Information

7.0 Walls:

Main Property

Type	CA Cavity
Insulation	A As Built
Wall Thickness Unknown	No
Wall Thickness [mm]	300
U-value Known	No
Party Wall Type	U Unable to determine

1st Extension

As Main Wall	Yes
Type	CA Cavity
Insulation	A As Built
Wall Thickness Unknown	No
Wall Thickness [mm]	300
U-value Known	No
Party Wall Type	U Unable to determine

8.0 Roofs:

Main Property

Type	PA Pitched (slates/tiles), access to loft
Insulation	J Joists
Insulation Thickness	250 mm
U-value Known	No

1st Extension

As Main	Yes
Type	PA Pitched (slates/tiles), access to loft
Insulation	J Joists
Insulation Thickness	250 mm
U-value Known	No

9.0 Floors:

Main Property

Location	G Ground floor
Type	S Solid
Insulation	A As built
U-value Known	No

1st Extension

As Main	No
Location	U Above unheated space
Type	T Suspended timber
Insulation	A As built
U-value Known	No

10.0 Doors:

Total Number of Doors	1
Number of Insulated Doors	0

11.0 Windows:

Glazed Area	T Typical
Proportion Double\Triple-glazed	100 %
Glazing	Double with unknown install date
Frame Type	Non-PVC frame
Draught Proofing	50 %

12.0 Ventilation & Cooling

No. of open Fireplaces	0
Mechanical Ventilation	No
Fixed Space Cooling	No

RdSAP

elmhurst energy systems

Summary Information

13.0 Lighting

Total number of light fittings	13
Total number of L.E.L. fittings	5

14.0 Main Heating1

PCDF boiler Reference	8140 Powermax, 155x, 82.00%
Main Heating Code	CGB CPSU with auto ign.
Heat Emitter	Radiators
Heat pump age	Unknown
Fuel Type	Mains gas
Flue Type	Balanced
Fan Assisted Flue	Yes
PCDF Heating Controls	0
Main Heating Controls	CBE Programmer, room thermostat and TRVs
PCDF Compensator	0
Percentage of Heat	100 %

14.1 Main Heating2

PCDF boiler Reference	0
Main Heating Code	
Percentage of Heat	0 %

15.0 Water Heating

Water Heating Code	HWP From the primary heating system

15.1 Hot Water Cylinder

Hot Water Cylinder Present	Yes

16.0 Solar water heating

Solar Water Heating	No

17.0 Waste Water Heat Recovery System

Total Number of rooms with bath and/or shower	2
Number of rooms with mixer shower and no bath	1
Number of rooms with bath and mixer shower	1
Is WWHRS present in the property?	No / Unknown

18.0 Flue Gas Heat Recovery System

Present	No

19.0 Photovoltaic Panel

Photovoltaic Panel	None

20.0 Wind Turbine

Terrain Type	Suburban
Wind turbine present?	No

21.0 Other Details

Electricity meter type	Single
Main gas	Yes

Appendix L: Test Property 2 Control Audit Pass Confirmation

Thu 21/02/2019 10:51

dea-qa@elmhurstenergy.co.uk

Elmhurst Audit Feedback

To toby@w-y-p.co.uk

Cc dea-qa@elmhurstenergy.co.uk

Click here to download pictures. To help protect your privacy, Outlook prevented automatic download of some pictures in this message.

Audit Feedback

Hello Toby Gledhill

Thank you for submitting your survey evidence, we are writing to inform you of the result of the audit.

Elmhurst Reference	C300-0001-000293
RRN	0618-9041-7292-5331-7944
Address	11, Grosvenor Park, YORK, YO30 6BX

Result	Met Requirements
Observations	We are pleased to inform you that this Energy Certificate, and its evidence, has met the required standard although we would like to highlight the areas below which we hope you will find useful and may help you to avoid potential issues in the future: 1. You have entered the ground floor HLP as 13.52m although, from the evidence you have provided, this shows that the entry should be 5.12m. This creates a SAP variance of +1 2. We have been unable to find any information relating the following area(s) within your evidence submission: • Electricity meter Please ensure you submit this evidence for future assessments. We would also like to take this opportunity to thank you again for your continued support of Elmhurst.
SAP Variance	1

If the above result has met the requirements, no further action is required as your audit has met the required standard.

Appendix M: Test Property 2 Photo Set

Image 1. Front elevation of control property for phase 2 of the EPC site study, showing integral garage.

Image 2. Rear elevation of control property for phase 2 of the EPC study, showing conservatory, which is open to the main dwelling, and therefore considered a part of the dwelling


Image 3. Kitchen, showing conservatory from within.


Image 4. Internal perimeter of the integral garage: this is considered an exposed, external wall according to RdSAP conventions.

Image 5. Wall thickness of the timber framed wall, which throughout the property measures 310mm.

Image 6. Loft insulation, measuring 200mm

Image 7. A wider view of the loft insulation, showing a consistent, relatively even level throughout. Note also here the view of the party wall, with the grey plastic sheet over it. It can be hard to identify the existence of a timber frame in place of a cavity constructed house (with use of brick and block, as opposed to brick and timber frame), because externally the two are very similar in appearance, but a loft can be a useful place to establish this. The loft of a brick and block, cavity constructed house would have blockwork party walls dividing the house from its neighbour, and these would be clearly visible. Here, the plastic sheet would raise suspicion for the experienced DEA – why is there no visible blockwork, and what sort of construction method would involve lining the party wall with a plastic membrane like this?

Images 8 & 9. A boiler with a thermal store: essentially a combination boiler, located in the airing cupboard off the second (top) floor landing. Make and model, along with model ‘qualifier’ (the specific model type) are clearly identifiable on the front panel of the boiler below.

Image 10. A traditional wall mounted thermostat, fitted in the property on construction in 2000.

Image 11. Thermostatic radiator valves, or ‘TRVs’ are common. These allow the temperature of individual rooms to be adjusted, while the room thermostat will control the overall temperature of the dwelling from its central location.

Image 12. The glazing gap is requested within RdSAP, as this can denote the efficiency, and possibly also the age of the glazing. Property 2 has the same ‘as built’ timber framed double glazed windows throughout.

Image 13. Finally, a breakdown of fixed light fittings and low energy bulbs is requested within RdSAP.

Appendix N: Control Property 2 EPC Inputs

RdSAP elmhurst energy

elmhurst energy systems

Summary Information

Surveyor:	C300-0001				
Name:	Toby Gledhill	**Title:** Mr.		**Tel Number:** 01904593570	
Survey Reference:	000293	**My Reference:**			
Current SAP rating:	C 70	**Potential SAP rating:**	C 79	**Emissions (t/year):**	5.250 tonnes
Current EI rating:	D 64	**Potential EI rating:**	C 73	**Fuel Bill:**	£1120

Property Details:

RdSAP version:	SAP 9.93
Reference Number:	C300-0001-000293
My Reference:	
Lodgement Required:	Yes
Regs Region:	England
EPC Language:	English
UPRN:	9494173578
Postcode:	YO30 6BX
Region:	North East England
House Name:	
House No:	11
Street:	Grosvenor Park
Locality:	
Town:	YORK
County:	
Property Tenure:	Owner-occupied
Transaction Type:	None of the above
Inspection Date:	09/02/2019
Process date:	11/02/2019

RdSAP Inputs

Property Description:

1.0 Property type:		H House
		M Mid-Terrace
2.0 Number of	**Storeys:**	3
	Habitable Rooms:	5
	Heated Habitable Rooms:	5
3.0 Date Built:	**Main Property**	I 1996-2002
	1st Extension	I 1996-2002

4.0 Dimensions:

Dimension type: Internal

Main Property

	Floor Area [m2]	Room Height [m]	Heat Loss Wall Perimeter [m]	Party Wall Length [m]
2nd Floor:	37.75	2.87	7.94	14.30
1st Floor:	37.75	2.56	7.94	14.30
Lowest Floor:	37.75	2.56	13.52	14.30
1st Extension				
2nd Floor:	0.00	0.00	0.00	0.00
1st Floor:	15.68	2.87	2.80	5.60
Lowest Floor:	15.68	2.56	2.80	5.60

5.0 Conservatory:

Is there a conservatory?	Yes
Is it thermally separated?	No
Floor Area [m2]	7.98
Double Glazed	Yes
Glazed Perimeter [m]	8.48
Room Height	1.5 Storey

RdSAP elmhurst energy systems

Summary Information

7.0 Walls:

Main Property

Type	TI Timber Frame
Insulation	A As Built
Wall Thickness Unknown	No
Wall Thickness [mm]	310
U-value Known	No
Party Wall Type	U Unable to determine

1st Extension

As Main Wall	Yes
Type	TI Timber Frame
Insulation	A As Built
Wall Thickness Unknown	No
Wall Thickness [mm]	310
U-value Known	No
Party Wall Type	U Unable to determine

8.0 Roofs:

Main Property

Type	PA Pitched (slates/tiles), access to loft
Insulation	J Joists
Insulation Thickness	200 mm
U-value Known	No

1st Extension

As Main	Yes
Type	PA Pitched (slates/tiles), access to loft
Insulation	J Joists
Insulation Thickness	200 mm
U-value Known	No

9.0 Floors:

Main Property

Location	G Ground floor
Type	S Solid
Insulation	A As built
U-value Known	No

1st Extension

As Main	No
Location	U Above unheated space
Type	T Suspended timber
Insulation	A As built
U-value Known	No

10.0 Doors:

Total Number of Doors	3
Number of Insulated Doors	0

11.0 Windows:

Glazed Area	T Typical
Proportion Double\Triple-glazed	100 %
Glazing	Double with unknown install date
Frame Type	Non-PVC frame
Draught Proofing	100 %

12.0 Ventilation & Cooling

No. of open Fireplaces	0
Mechanical Ventilation	No
Fixed Space Cooling	No

RdSAP elmhurst energy

elmhurst energy systems

Summary Information

13.0 Lighting

Total number of light fittings	22
Total number of L.E.L. fittings	6

14.0 Main Heating1

PCDF boiler Reference	8140 Powermax, 155x, 82.00%
Main Heating Code	CGB CPSU with auto ign.
Heat Emitter	Radiators
Heat pump age	Unknown
Fuel Type	Mains gas
Flue Type	Balanced
Fan Assisted Flue	Yes
PCDF Heating Controls	0
Main Heating Controls	CBE Programmer, room thermostat and TRVs
PCDF Compensator	0
Percentage of Heat	100 %

14.1 Main Heating2

PCDF boiler Reference	0
Main Heating Code	
Percentage of Heat	0 %

15.0 Water Heating

Water Heating Code	HWP From the primary heating system

15.1 Hot Water Cylinder

Hot Water Cylinder Present	Yes

16.0 Solar water heating

Solar Water Heating	No

17.0 Waste Water Heat Recovery System

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Photovoltaic Panel	None

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Terrain Type	Suburban
Wind turbine present?	No

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Electricity meter type	Single
Main gas	Yes