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Fuel Poverty Policy and Non-Heating Energy Uses

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Contents

1 Introduction

Fuel poverty in England and the UK more widely is routinely talked, written and thought about as a matter of achieving affordable warmth. Heating is clearly a crucial use of energy in terms of the impact that living at low temperatures can have on health, particularly in the context of cooler climates like the UK and especially for those who are most vulnerable to negative health impacts (such as the elderly or sick). However, energy is used by domestic consumers for many purposes other than heating, both at home and in moving around.

In research in the DEMAND Centre we have been interested in examining the range of ways in which energy use can be thought of as a basic need, entitlement or right. This led us to focus part of our work on how fuel poverty policy defines the 'necessary' uses of energy that it is supposed to support, and then in turn how policy measures intended to address fuel poverty do or do not consider energy uses other than heating. Our focus here is on uses of energy at home, but other ongoing research in the DEMAND Centre is focusing also on energy use for transport.

This working paper provides background information to support two DEMAND Research Insight notes (available at www.demand.ac.uk).

- The first of these '*What energy uses matter? Fuel Poverty Beyond Heating*' examines the grounds on which energy uses can be considered essential for enabling a minimally-decent quality of life, drawing on both theoretical perspectives and empirical evidence. Although fuel poverty in the UK focusses predominantly on affordable warmth, multiple other energy services are essential for well-being. It argues organisations involved in developing and scrutinising fuel poverty policy need to give these non-heating services more careful and balanced consideration.

- The second '*What counts as 'required' energy? principles of need in fuel poverty policy*' focusses more specifically on how non-heating energy uses are accounted for in the current fuel poverty statistics methodology. Different underlying principles of need are embedded in the methodology and allowances for variation between households are inconsistent. It is argued that making changes to set defined 'standards of service' for all energy use categories has potential benefits and should be explored further.

This background working paper provides largely descriptive information, drawn together to support the discussion and arguments found in the two Research Insights.

The content of the paper addresses three questions:

1. How does fuel poverty policy in England include energy uses other than for heating within its definition and remit?[1]

2. To what extent are non-heating energy uses addressed within recent fuel poverty mitigation measures?

3. On what basis does the current fuel poverty statistics methodology (that generates annual estimates of the numbers of households in fuel poverty in England) define the 'required' energy consumption for non-heating uses?

In focusing on energy uses other than heating, our intention is to open up discussion and encourage greater scrutiny of aspects of fuel poverty policy which have, to date, been rather under-examined, despite the degree of recent policy development and discussion resulting from the 2012 Hills Review. This working paper is designed to be predominantly descriptive rather than evaluative, focussing on outlining the current situation and policy changes over the past 5-10 years rather than arguing for future change. It is recognised that there are both basic principles and many practical questions that must be considered

[1] This report focusses only on England, in part because of the differences in how fuel poverty is defined and calculated in other parts of the UK.

2 Non-heating energy uses in the definition of fuel poverty

Definitions of fuel poverty matter, because they influence both how the problem of fuel poverty is understood (what fuel poverty 'is'), and how it is measured and represented in statistics.[2] It is therefore important to see which energy uses are included in the English definitions. Here we focus on both the 'old' and the 'new' way of defining fuel poverty.

In the Fuel Poverty Strategy 2001, fuel poverty was officially defined as:

> *"A household is in fuel poverty if, in order to maintain a satisfactory heating regime, it would be required to spend more than 10% of its income (including Housing Benefit or ISMI) on all household fuel use."*[3]

Here it is the cost of *all* household fuel consumption that determines whether a household can be classed as fuel poor. Energy that is required for non-heating purposes is therefore incorporated alongside consumption from heating, but it is the 'heating regime' that is particularly picked out in terms of a standard to be achieved (see later discussion).

Following the Energy Act 2013, a new official definition of fuel poverty was adopted in England, informed by recommendations made by the 2011-2012 Fuel Poverty Review (hereafter the 'Hills Review'). Termed the 'Low Income High Costs' indicator, under this definition a household is considered to be fuel poor if:

> *"•they have required fuel costs that are above average (the national median level)*
>
> *•were they to spend that amount, they would be left with a residual income below the official poverty line."*[4]

Here, reference is made to 'required fuel costs,' although exactly *which* energy uses are included under this umbrella is not immediately obvious from the definition. Further elaboration in the Hills Review reveals that this definition, like the previous, is indeed designed to capture both heating and non-heating forms of energy use. Definitions of fuel poverty in England have therefore always included energy uses other than heating.

However, there is relatively little written in policy documents or other sources on the *reasoning* behind the inclusion of non-heating uses in these fuel poverty definitions.[5] The Final Report of the Hills Review, for example, makes no mention of this, whilst the Interim Report provides a very brief explanation in a footnote before directing the reader toward the 2001 Fuel Poverty Strategy for a fuller explanation. Other than this Strategy, as far as we were able to find no recent policy or related documents provide any consideration of the inclusion of non-heating energy consumption in fuel poverty definitions and indicators.

Going back 14 years to the 2001 Fuel Poverty Strategy provides some limited explanation. This notes that whether an allowance should be made for non-heating energy uses is an important factor to consider when developing any definition of fuel poverty. Two brief explanations for the inclusion of non-heating energy uses are provided in Chapter 4 and the Annex section. The first is that *"Excluding other household fuel uses could have a marked effect on estimates of the number of fuel poor households"*[6], which is more of an implication than an explanation. The second rationale is that other energy uses might also be considered essential. It is stated that *"no worthwhile distinction can be made between fuel used for heating and hot water, and that for other, equally essential purposes"*[7] and that *"Fuel use for lighting and cooking purposes could also be considered as essential use."*[8]

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[2] Hills, J. (2012) *Getting the Measure of Fuel Poverty: Final Report of the Fuel Poverty Review.* London: Centre for Analysis of Social Exclusion, London School of Economics.

[3] Defra, DTI. (2001) *The UK Fuel Poverty Strategy*. London: Defra/DTI, p.30

[4] DECC (2013) 'Fuel poverty statistics'. Online at: https://www.gov.uk/government/collections/fuel-poverty-statistics

[5] The 2005 peer review of the fuel poverty methodology by Tom Sefton and John Chesshire did discuss non-heating energy uses and fuel poverty in some detail (see Section 6 below) – however, they did so in relation to how such uses were incorporated into fuel poverty modelling, *not* the underlying rationales or justifications for their inclusion.

[6] Defra, DTI (2001) The UK Fuel Poverty Strategy, p.107

[7] Defra, DTI (2001) The UK Fuel Poverty Strategy, p.30

[8] Ibid., p.107

For these reasons, *"It was therefore decided that the definition of fuel poverty should be based on all household expenditure on fuel, including that used for non-heating purposes."*[9] Therefore, although various non-heating energy uses are included on the basis that they are 'essential,' the reason *why* they are considered essential is not stated (whereas, as noted later in this report, space heating is very clearly identified as vital for health reasons). Also, beyond the specific mentions of lighting, cooking and hot water, exactly *which* other non-heating energy uses are essential is not fully specified, but is instead left relatively open.

The decision to include non-heating energy consumption, and the rationales behind it, was supported by a government consultation undertaken prior to the development of the 2001 Strategy and the adoption of the then official definition. This consultation asked: 'Should fuel for non-heating purposes be considered when deciding whether a household is fuel poor?' Again, it is interesting to note that this question does not ask *which* non-heating purposes should be included. The Strategy states that the consultation responses *"showed a strong view that other fuel use should be included in calculating the total amount of fuel needed (54% in favour, 40% not commenting, 6% offering alternative suggestions)."*[10]

Details of exactly how non-heating energy uses figure in the translation of the fuel poverty definition into the generation of fuel poverty statistics are provided in section 5 (and Annex 5) of this document.

3 Comparing heating and non-heating energy uses in policy discourse

To examine the extent to which energy uses other than heating have figured in recent policy discussion on fuel poverty, we undertook a brief content analysis of five of the most recent DECC fuel poverty documents (see Table 1 in Annex 1). We found that words relating to heating and warmth are mentioned much more frequently than those relating to some common non-heating energy uses – in total, heat/heating/warm/warmth were together mentioned 377 times, whilst there are only 30 mentions in total of words relating to lighting, cooking, appliances or water heating.

Therefore, in general it seems that non-heating uses receive much less attention than heating and warmth in the way that fuel poverty is discussed and represented. A more qualitative analysis of policy discourse also supports this assertion. For example, the interim and final reports of the Hills review both present the concern of fuel poverty as about people's ability to *keep warm*. Agreeing with Warm Homes and Energy Conservation Act 2000, Hills states that the concern of fuel poverty should be for those *"living on a lower income in a home that cannot be kept warm at reasonable cost"*.[11] Moreover, the rationale for home heating being an issue of concern is outlined in detail over several pages of both the Interim and Final Reports, in contrast to the very brief treatment of other energy uses noted earlier. This illustrates that the major health and well-being concerns that underlie most concerns for fuel poverty in England are related to maintaining adequate bodily warmth.

Several DECC documents have a similar focus on heating as the key energy service that fuel poverty policy should seek to make affordable. For example, the opening sentence of the 2013 'Fuel Poverty: a Framework for Future Action' document states that *"Ensuring that people are able to keep warm in their homes is a priority for this Government."*[12]

4 Non-heating energy uses in fuel poverty mitigation policies

Another way of considering the position of non-heating energy consumption in fuel poverty policy is through their inclusion in measures intended to address and mitigate fuel poverty. Even if the definition of fuel poverty includes required uses other than heating, this does not necessarily mean that mitigation measures will also recognise and focus upon these other uses. A summary of current and recent measures examined can be found in Annex 2.

[9] Ibid., p.107
[10] Ibid., p.107
[11] Hills Review Final Report, p.6-7
[12] DECC (2013) *Fuel Poverty: a Framework for Future Action*, London: DECC, p.7

4.1 Current Measures

A long established way of mitigating fuel poverty is to provide direct financial help to people who may be struggling to pay their energy bills. There are currently three such measures in operation – the Winter Fuel Payment, the Cold Weather Payment and the Warm Homes Discount. The first two are taxpayer funded schemes and provide direct monetary payments to the bank accounts of eligible households.[13] The Winter Fuel payment is provided each winter to pensioner households, whilst the Cold Weather payment only comes into effect during a period of particularly cold weather. Meanwhile, the Warm Home Discount is funded by the UK's energy suppliers, and offers eligible households a rebate of around £120-140 on their winter electricity bill, usually between October-March. These three measures help with the affordability of all energy consumption, not only space heating. However, all three also have names that suggest a focus on heating and warmth, and all three are only paid out during the colder months or, in the case of the Cold Weather Payment, during periods of exceptionally cold weather – this suggests that their primary underlying rationale is to help with the cost of home heating.

Another set of policies provide funding support for measures that improve domestic energy efficiency. Rather than supplementing incomes, the aim here is to help fuel poor householders reduce their energy consumption (and, therefore, their overall energy bills) and/or to improve the quality of the energy services they are able to access.

The current policy legislation that falls within this spectrum is the Energy Company Obligation (ECO). This officially began in early 2013 and offers various subsidies to householders that help fund energy efficiency measures. It is aimed at those on low incomes, or those with 'hard to treat' properties, and is funded via a levy on household fuel bills. There are three components to ECO:

i. The *Carbon Saving Obligation* is <u>not</u> targeted at those on low incomes who might be considered vulnerable to fuel poverty. Instead, it focusses on households with 'hard-to-treat' properties,[14] and covers the installation of measures like solid wall and hard-to-treat cavity wall insulation that, due to their expense, ordinarily can't be financed solely through the Green Deal.[15] All the measures supported relate to improving the energy efficiency of heating the home.

ii. The *Carbon Saving Communities Obligation* is an obligation focussed on specified localities of low income and 'hard-to-reach' households in rural areas.[16] It is expected to deliver a combination of lower-cost loft and cavity wall insulation, alongside some solid wall insulation.[17] More precisely, the ECO Legislation[18] states that measures that can be funded under this relate to improving thermal insulation and connections to district heating systems:

"(a) a recommended measure installed to improve the insulating properties of the premises; or

(b) a connection to a district heating system where that connection is made to premises which have loft or wall insulation."

iii. The *Affordable Warmth Obligation* (termed the *home heating cost reduction obligation* in the ECO legislation) provides support measures to consumers living in private tenure properties that receive particular means-tested benefits (i.e. are on a low-income).[19] The official government ECO webpage also states that this measure *"supports low-income consumers that are vulnerable to the impact of living in cold homes, including the elderly, disabled and families"*.[20] The ECO legislation[21] specifies the qualifying support measures as:

[13] See Annex 2 for details of eligible households

[14] The Electricity and Gas (Energy Companies Obligation) Order 2012

[15] DECC (2014) 'Helping households to cut their energy bills'. Online at: https://www.gov.uk/government/policies/helping-households-to-cut-their-energy-bills/supporting-pages/energy-companies-obligation-eco

[16] Energy Companies Obligation Order 2012. 15% of each supplier's obligation is to be used to upgrade low-income households in specifically *rural* areas.

[17] DECC (2014) *Fuel Poverty: A Framework for Action*

[18] Energy Companies Obligation Order 2012; p.10-11

[19] Ibid.

[20] DECC (2014) 'Helping households to cut their energy bills'.

[21] Energy Companies Obligation Order 2012; p.12

"(a) the installation of a measure that will result in a heating saving;

(b) the repair of a qualifying boiler where the repair will result in a heating saving and where the repair is accompanied by a warranty for one or two years; or

(c) the replacement of a qualifying boiler which will result in a heating saving"

In summary, all of these current ECO measures are related to efficiency interventions intended to reduce energy costs associated with space heating (and potentially hot water use where boiler replacement is involved). No other forms of energy use, or efficiency improvements related to these, are targeted.

4.2 Previous measures

There are a number of fuel poverty mitigation schemes that have ended relatively recently: Warm Front, the Carbon Emissions Reduction Target, and the Community Energy Saving Programme (CESP) (ending in 2013, 2012 and 2012, respectively). Warm Front was a taxpayer funded program introduced in England following the 2001 Fuel Poverty Strategy. It offered grants of up £3,500 for eligible households in order to fund efficiency measures related to space heating (insulation and heating technologies), plus hot water use in relation to boiler efficiencies and tank insulation.[22]

The Community Energy Saving Programme (CESP) was a supplier obligation that ran from 1 October 2009 to 31 December 2012. Under the program, energy suppliers over a certain size were obligated to deliver energy saving measures to domestic customers living within low income areas of Britain (these low-income areas were specified using the Income Domain of the Indices of Multiple Deprivation). CESP was designed to promote a 'whole house' approach and to treat as many properties as possible within these defined geographical areas.[23] The majority of qualifying actions suppliers and generators could undertake to meet their CESP obligations were targeted at improving the efficiency and affordability of space heating, such as a variety of insulation measures, window glazing, and draft proofing. Replacement of old and inefficient boilers was also included, and so water heating was captured.

CESP also included two other types of qualifying action that targeted elements of non-heating energy consumption. First was the installation of micro-generation technology, such as solar PV, with the aim of improving the affordability of household electricity consumption. Second was the provision of home energy advice packages, which focused partly on the efficient use of space heating systems but also on how electrical appliances *"may be used more effectively to achieve energy efficiency savings or energy savings"*.[24] However, provision of home energy advice was only designed to be a minor action under CESP: no more than 1% of a generator's or a supplier's carbon emissions reduction obligation could be achieved by this method.[25]

The Carbon Emissions Reduction Target (CERT) programme ran from 1 April 2008 – 31 December 2012. It obligated all domestic energy supplies with a customer base in excess of 250,000 to make savings in the amount of CO_2 emitted by householders by promoting the uptake of a range of low carbon energy solutions.

All domestic energy customers were eligible for energy efficiency measures funded under CERT. However, suppliers were also obligated to ensure a certain amount of support was targeted specifically at those considered 'vulnerable' to fuel poverty. At least 40% of their carbon savings had to be achieved by actions carried out in the 'priority group'[26] – that is, those aged 70 or over and/or in receipt of certain income-related benefits.

The qualifying support measures were broadly defined and included any action that would achieve a

[22] Gov.uk (2012) 'Warm Front Scheme.' Online at: http://webarchive.nationalarchives.gov.uk/20121205174605/https://www.gov.uk/warm-front-scheme/overview

[23] Ofgem (2015) 'Previous energy efficiency schemes.' Online at: https://www.ofgem.gov.uk/environmental-programmes/energy-companies-obligation-eco/previous-energy-efficiency-schemes

[24] The Electricity and Gas (Community Energy Saving Programme) Order 2009, p.16

[25] Ibid., p.11

[26] The Electricity and Gas (Carbon Emissions Reduction) Order 2008, p.8

reduction in carbon emissions,[27] so long as it was promoted for the purpose of:

"(a) achieving improvements in energy efficiency;

(b) increasing the amount of electricity generated or heat produced by microgeneration;

(c) increasing the amount of heat produced by any plant which relies wholly or mainly on wood; or

(d) reducing energy consumption"[28]

Therefore, in terms of energy efficiency and reductions in consumption, initially CERT did not focus solely on measures that aimed to reduce the energy demands of space heating (unlike ECO or Warm Front). Indeed, a range of measures and technologies were implemented by the energy suppliers, including low-energy lighting, shower regulators, standby savers, and energy efficient cold appliances, alongside loft and wall insulation measures.[29]

4.3 The CERT experience

As CERT provides the one recent example where there has been the possibility of interventions addressing the efficiency of a greater range of energy uses, its history and the debate surrounding the efficacy of its implementation merits a longer discussion.

By early 2009 there began to be complaints about energy companies sending low-energy light-bulbs (specifically compact fluorescents (CFLs)) unsolicited to their customers, as part of meeting their CERT obligations. These critiques centred on various factors:

- That the bulbs were being sent unsolicited and via mass mail-outs. Some saw this as intrusive, and as evidence of a poor ethos by the energy companies who were merely trying to dispense with their obligations as quickly as possible[30]
- That it was unclear how many of the sent bulbs were actually being used by customers[31]
- That, even if they were being used, the bulbs were relatively ineffective in comparison to loft and wall insulation measures[32]

The energy companies defended the practice of sending CFLs. For example, Npower argued that the bulbs should be seen as *"part of a mix of energy-efficient measures"*.[33] However, the practice of sending bulbs unsolicited was banned in June 2009[34] – although this did not come into force until 2010 and there was evidence that energy companies sent out many bulbs prior to the deadline. DECC's official rationale for stopping the measure was that it was not clear that the bulbs were being used, and that enough had now been distributed to satisfy demand.

On 30th July 2010, CERT was extended from March 2011 to December 2012, following an earlier consultation entitled 'Paving the way for a Green Deal – extending the Carbon Emissions Reduction Target supplier obligation to December 2012.' This extension brought a number of further changes and amendments. Most significantly for our interest, there was a refocus on insulation as a support measure, with non-heating elements playing a reduced role. At least 68% of the measures delivered by each energy company had to come through professionally installed insulation. With a further 12% added for DIY insulation, around 80% of the scheme now focussed on insulation. Previously, around 60% of the delivered measures had come from *both* professional and DIY work. Furthermore, following the earlier ban on CFL mail-outs, energy companies were now completely banned from even promoting CFLs in order to prioritise insulation.[35]

In November 2010, the coalition government released a further consultation entitled "The Role of Appliances and Consumer Electronics in CERT." This asked whether it was appropriate for CERT to continue support for energy efficient appliances and technologies that related to non-heating aspects of energy consumption. DECC stated that the consultation did not *"doubt the carbon saving benefits*

[27] Ibid., p.4
[28] Carbon Emissions Reduction Order 2008, p.7
[29] Ofgem (2013) *The final report of the Carbon Emissions Reduction Target (CERT) 2008-2012.* London: Ofgem
[30] Personal correspondence
[31] BBC News (2010) 'Npower criticised over low energy light bulb handout'. Online at: http://news.bbc.co.uk/1/hi/uk/8437778.stm
[32] Ibid.
[33] Ibid.
[34] The Electricity and Gas (Carbon Emissions Reduction) (Amendment) Order 2009
[35] The Electricity and Gas (Carbon Emissions Reduction) (Amendment) Order 2010

of the products in question (over less efficient alternatives)", but did question whether *"if in practice, securing these benefits represents a cost-effective use of the CERT and therefore whether CERT should be the mechanism to continue to promote these."*[36] DECC also noted that decisions on the inclusion of appliances and electronics were *"vitally important,"* as they would impact upon *"the level of support available for key heating and insulation measures, as more of these measures will be installed if there are fewer competing options for energy suppliers to support."*[37]

Although DECC received a number of responses to this consultation, they do not appear to have published a final report on the consultation (or at least none appears to be available online).

5 Calculating 'required energy consumption' in fuel poverty modelling

It was established in Section 2 that non-heating energy uses are included within the current (and past) definition of fuel poverty. One of the key roles of this definition is to provide the basis for the generation of statistics that estimate the number of households in fuel poverty in England, its distribution across the population, and also 'depth' or severity of this problem – defined as the amounts by which the 'required' energy costs of fuel poor households exceed the threshold of what is considered 'reasonable' energy costs.[38]

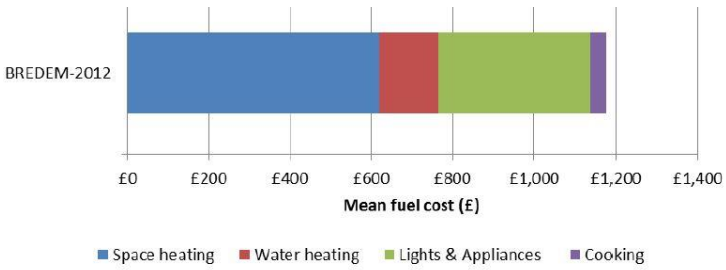
These statistics are produced through modelling, which generates separate estimates for three core elements: [39]

- income – data collected from the English Housing Survey is utilised to estimate the total net income of each household
- energy prices
- the 'required' energy consumption (heating *and* other uses) of each modelled household

It is the last of these three areas – the 'required' energy consumption of households – that is of interest to this report.

The estimates of the 'required' energy consumption of modelled households are currently generated using the 'BREDEM-2012' model, developed by the Building Research Establishment (BRE) in England.[40] Separate calculations are made to work out the required energy consumption in kWh of: lighting; appliances; pumps and fans; cooking; and water heating.[41] The resulting calculated mean cost (across all households) of required energy for these different categories of end use is shown in Figure 1. Approximately 55 per cent of the average (mean) modelled household fuel bill goes toward space heating, whilst the remaining 45 per cent goes toward non-heating consumption.[42] Thus, the categories are almost evenly split.

Fig 1: Mean Calculated Fuel Costs by Use (DECC 2014)



Both the original fuel poverty definition and the recently adopted LIHC definition adopt a so-called 'needs-based' approach to calculating household fuel consumption (and so fuel costs). That is, they propose that what matters for fuel poverty is what households *need* to consume and spend on fuel, not what they *actually* consume – hence the fuel poverty model is supposed to estimate 'required' energy consumption. One advantage of this approach that is often referred to is that it accounts for the fact that many fuel poor households will be under-heating their homes due to

[36] DECC (2010) *Consultation on the Role of Appliances and Consumer Electronics in CERT.* London: DECC, p.5
[37] DECC (2010) *Consultation on the Role of Appliances and Consumer Electronics in CERT.* Online at: http://webarchive.nationalarchives.gov.uk/20121217150421/http://www.decc.gov.uk/en/content/cms/consultations/appliance_cert/appliance_cert.aspx
[38] Hills Review Final Report
[39] DECC (2014) *The Fuel Poverty Statistics Methodology and User Manual*. London: DECC
[40] BRE Group (2015) 'BRE Domestic Energy Model (BREDEM 2012)'. Online at: http://www.bre.co.uk/page.jsp?id=3176
[41] DECC (2014) *The Fuel Poverty Statistics Methodology and User Manual.* London: DECC
[42] DECC (2014) pg 7

affordability problems – their homes will be less warm than they really 'need' to be (again a heating based justification). Accordingly the Hills Review stated that the previous definition had *"the key strength that it focuses on required, not actual, energy spend"*,[43] and proposed that this feature should remain in the new LIHC definition.

However, in BREDEM-2012 different modelling methods are used to calculate the amount of energy consumption 'required' for different energy uses, and distinct underlying principles of what constitutes 'needed' energy consumption are also evident. The next sections outline in more detail the calculation method utilised for each energy usage.

5.1 How the 'required' energy consumption for space heating and hot water are derived through a 'standard of energy service' approach

The calculations of required energy consumption for heating and hot water share a similar feature – both begin by defining *standards of energy service* that different types of households 'need' to be able to achieve. Following this, the amount of energy consumption required to achieve this standard is *then* calculated, taking into account the energy efficiency of different types of homes and heating systems.

However, the calculations for space heating and hot water do differ in terms of the principles of need upon which their respective standards-of-energy-service are based. For space heating, the standard is based on 'expert' knowledge of what temperatures different types of households are thought to 'need' in order to stay healthy – it may therefore differ from what such households *actually* do. For hot water, the standard is based on estimates of *actual* consumption, in terms of what constitutes 'typical' or 'average' hot water usage for households in England – it is therefore meant to reflect and track what households normally do, taking this as the marker of 'required' consumption

The respective approaches for calculating required energy consumption for space heating and hot water in BREDEM-2012 are now described in more detail. All the information that follows has been translated from the BRE's 'Technical Report'[44] on BREDEM-2012, with additional clarification provided by a member of the BRE involved in the model's ongoing development.

5.1.1 Space Heating

For space heating, the initial 'standard of energy service' is a heating regime that specifies the number of hours the central heating system is turned on for, and its temperature in different rooms. There are four different regimes in total (see Annex 3 for more details), in order to attempt to account for householders that are likely to spend weekdays at home, and for houses that are deemed to be 'under occupied.' In this way, the heating needs of different social groups – for example, pensioners who might spend a greater amount of time at home – are to some degree accounted for. These heating regimes are supposed to represent what households 'need' or 'require' in order to maintain a healthy living environment, with the temperatures defined based on 'expert' knowledge of what supposedly constitutes a healthy living temperature.

Having defined the standard of energy service (in the form of a heating regime) needed for each household, the energy consumption in kWh required to achieve each heating regime is then approximated using the BREDEM-2012 model. This calculates the energy consumption necessary in order for each type of dwelling to meet its designated heating regime standard, taking into consideration many details about heating systems / boilers, home insulation, dwelling construction and materials, and geographic location. Accordingly, data on the detailed efficiency performance of representative households across different categories of house and household type is incorporated into the modelling, as derived from the English Housing Survey. Therefore, differences in household needs are again accounted for to some degree, recognising that those households with poor insulation or inefficient boilers will need to consume

[43] Hills, J. (2011) *Fuel Poverty: The Problem and its Measurement. Interim Report of the Fuel Poverty Review.* London: Centre for Analysis of Social Exclusion, London School of Economics.

[44] Henderson, J. and Hart, J. (2013) *BREDEM 2012 – A technical description of the BRE Domestic Energy Model.* Watford: BRE.

more energy in order to heat their home to the 'required' heating regime compared houses that are more insulated and efficient. More detailed descriptions of the methodology for calculating the energy requirements for space heating can be found in DECC's 2014 document 'The Fuel Poverty Statistics Methodology and User Manual' and BRE's 'Technical description of the BRE Domestic Energy Model'.

5.1.2 Hot water

For hot water, the initial 'standard of energy service' is the amount of heated water in litres that is 'required' by a household. Rather than being pre-defined, this is calculated through BREDEM. This standard attempts to represent patterns of 'typical' hot water consumption by households in England (in contrast the standard-of-service for space heating is 'expert' defined rather than based on actual household usage), and includes an allowance for three categories of hot water usage: showers, baths, and 'other uses'.[45]

The calculations of litres of hot water required for showering takes into account the flow rate of different types of showers (an element incorporated for the first time in BREDEM-2012, having not been in previous iterations of the model) and the number of showers taken per day. The data for shower flow rates came from a number of different sources, which together provided the BRE with just enough information to complete the equation. The number of showers per-day figure is supposed to represent what is 'typical' for individuals in England (it is assumed that each person in a household has approximately one shower per day), and takes into consideration the number of people living within a property – larger households are assumed to have more showers.

The litres of hot water required for baths takes into account the assumed number of baths a household takes per day. This is dependent both on the number of people living within a household (it is assumed that the greater the number of occupants, the more baths that will be taken) and whether that household has a shower (it is assumed that those households where a shower is present take fewer baths).

The number of litres required for 'other uses' of hot water is determined purely by the number of household occupants – again, larger households are deemed to require a greater level of hot water usage.

Having established how much hot water consumption is required for the size of household, the amount of energy consumption in kWh that is required to supply this amount of hot water is then calculated. At this stage, a correction is made to account for differences in energy requirements across the year, since water stored during the colder months of the year requires more energy to raise it to the desired temperature. There are then a further set of calculations that account for differences in the energy efficiency of household water heating systems (e.g. due to boiler efficiency, whether the hot water cylinder insulated),[46] on the grounds that less efficient systems consume more energy to generate the same amount of hot water.

When the hot water calculations are incorporated into the generation of fuel poverty statistics no further adjustments are made, for example to take account of different patterns of 'being at home' during the day.

The hot water calculations provide an example of where changes have been made over time to reflect indicators of shifting levels of actual consumption. A 2005 BRE report[47] considered a proposal to increase required hot water consumption by 20%, reflecting increases in average consumption levels. This confirmed an apparent gap between data from the 1998 EFUS and the then BREDEM model (at the time, the 2001 version – BREDEM-12) and recommended the increase be applied. This change over time is an outcome of the underlying principle of need that being utilised – because 'required' hot water usage is supposed to reflect what is typical for households to use, rather than being based on a somewhat fixed expert standard as for space heating, this 'required'

[45] There is also a separate calculation for the energy requirements of electric showers. However, according to DECC's (2014) Fuel Poverty User Handbook this is included under 'appliance consumption' when running the fuel poverty model.

[46] Henderson, J. and Hart, J. (2013) *BREDEM 2012 – A technical description of the BRE Domestic Energy Model*. See particularly p.15, 'Water heating system losses'

[47] BRE (2005) *Estimates of hot water consumption from the 1998 EFUS. Implications for the modelling of fuel poverty in England.* Watford: BRE.

usage is liable to change as societal conventions involving hot water usage evolve. This analysis also considered evidence of variation by different types of households (including by age and income) and whether this warranted further adjustments to the fuel poverty calculations. The conclusion was that "*this research has not provided specific and consistent evidence which would allow the application of different standards of hot water use to different household groups in a balanced way*" (p7). Older households (people over 65) were, for example, found to use *less* hot water on average than other households, suggesting that they were not disadvantaged as a consequence of all household sizes getting the same allocation. The logic that they may be 'under-consuming' relative to a required standard of 'need' was not deployed here.

The full calculations for hot water energy consumption are covered in Annex 5.

5.2 How the 'required' energy consumption for other non-heating uses are derived based on typical actual consumption

In contrast to the approaches adopted for space heating and hot water, the calculations of required energy consumption for other purposes (categorised as lighting, appliances, pumps and fans, and cooking in the BREDEM-2012 model) do *not* involve specifying standards of energy service.[48] This stage is missed out, and instead the process jumps straight to defining the figure of 'required' energy consumption in kWh. For each of the energy uses, this figure is designed to reflect the 'typical' or 'average' amount of energy that is actually being consumed (in kWh) by households.

These calculations take into account fewer differences between households than is accounted for in the space-heating and hot water calculations – illustrated in full in Annex 4. Unlike the space heating calculations, no account is taken of different patterns of being at home during the day. Nor is there any consideration of the different energy efficiency levels of technologies[49] (e.g. the different energy ratings, and therefore consumption per hour, of fridges or TVs) in different types of household – whilst building and boiler efficiency is central to the space heating calculations, and the efficiency of the water heating system is considered in relation to the energy required for hot water usage. As acknowledged in a 2005 Peer Review of the fuel poverty methodology[50], this lack of differentiation is partly the result of the particular calculation approach adopted – it is easier to incorporate and highlight variation between households if a 'standard of energy service' method is utilised, as it is for space heating and hot water. However, some other simple variations between households are incorporated – specifically household size and floor area, so that bigger homes and/or households will be deemed to have a higher 'required energy' consumption than smaller ones.

As the details do vary between the different categories of non-heating energy use, and there are some exceptions to the general position outlined above, we now provide a more detailed account of the principles of how the different categories are calculated in BREDEM-2012. Once again, all the information that follows has been translated from the BRE's 'Technical Report' on BREDEM-2012, with additional clarification provided by a member of the BRE involved in the model's ongoing development. A further level of technical detail, that reproduces parts of the Technical Report, is provided in Annex 5.[51]

5.2.1 Lighting

The calculation of a household's required energy consumption for lighting aims to reflect the 'typical' or 'normal' amount of energy that is consumed on

[48] For example, following a standard-of-service approach for lighting would mean first specifying how many lumens different rooms should be lit to, for how many hours etc. (perhaps varying these figures between household types), and *then* calculating 'required energy' (in kWh) needed to meet these service standards.

[49] The one exception here is the required energy consumption for lighting, which does make some adjustment to account for low energy lighting, although in a much more basic way than building efficiency is incorporated into the space heating calculations.

[50] See Sefton, T. and Chesshire, J. (2005) *Peer Review of the Methodology for Calculating the Number of Households in Fuel Poverty in England: Final Report to DTI and DEFRA.* London: DEFRA/DTI.

[51] Nb. DECC's Fuel Poverty Methodology User Manual (2014) does not give details of how lighting, appliances or hot water are calculated. Instead, readers are directed toward the BREDEM-2012 Technical Report which is difficult for non-specialists to understand.

lighting in homes in England, relative to the total floor area of the home and the number of people living within in. The original figures that are used to determine what constitutes 'typical' consumption come from the 1998 Energy Follow-up Survey, which included data on energy consumption from a sample of households.

Some adjustments are made in the calculations to take into account the window area of homes (which impacts upon the amount of daylight that enters) and daylight availability. The data on daylight availability comes from weather data, and takes into account both time of year and the geography of the England. Data on window areas for different types of houses is derived from the English Housing Survey.

A further adjustment is made to take account of the proportion of low energy light bulbs in the household, with sampled data for different types of household again coming from the 1998 Energy Follow-up Survey.

When the lighting calculations are incorporated into the generation of fuel poverty statistics no further adjustments are made, for example to take account of different patterns of 'being at home' during the day.

The full calculations for lighting consumption used in the BREDEM-2012 model are covered in Annex 5.

5.2.2 Appliances

Aside from the separate calculations for lighting, pumps and fans, cooking, and water heating, the energy required for all other non-heating purposes is grouped together into one equation that that represents 'appliances.' There is no breaking down into different types of appliances such as fridges, freezers, dishwashers, or televisions, with these all treated as one category of consumption.

As with lighting, this calculation aims to reflect the 'typical' or 'normal' amount of energy that is consumed on appliance usage in homes in England. Although this is a complex aggregate category, the calculations for appliances are less complex than those for lighting. Again, the modelling takes account of the total floor area of the home and the number of occupants (it is assumed that the greater the floor area, or the greater the number of occupants, the greater consumption of energy for appliances). The source of data on what constitutes 'typical' consumption comes from the 1998 Energy Follow-up Survey (EFUS), checked against other more aggregate indicators. One further adjustment factor aims to account for variation in appliance energy consumption over the course of the year, since this tends to rise during the winter months.

When the appliance calculations are incorporated into the generation of fuel poverty statistics no further adjustments are made, for example to take account of different patterns of 'being at home' during the day, or different patterns of ownership of high or low efficiency appliances.

The full calculations for appliance consumption are covered in Annex 5.

5.2.3 Pumps and fans

Rather oddly, 'pumps and fans' have their own calculation separate from that used for other appliances, even though they are not a particularly significant energy use.[52] This separation has existed historically in several iterations of the BREDEM model, in part because the consumption of these technologies has been considered by BRE to be relatively easy to predict. Moreover, they are also related to the space heating system which has always been covered in more detail in the model.

The calculation is relatively simple and involves summing together standard figures of the kWh/yr consumption of different types of pumps and fans (figures found in the BREDEM-2012 Technical Report). Once again, these figures are meant to represent what is deemed to be 'typical' consumption for the technology in question, based on data that has been amalgamated from various sources over several years. Data on the pumps and fans in place in different households are derived from the EHS.

When the pumps and fans calculations are incorporated into the generation of fuel poverty statistics no further adjustments are made.

[52] Nb. The method for calculating the consumption of pumps and fans is not described in the DECC Fuel Poverty Methodology User Manual (2014). Despite this, DECC confirmed to us that the separate pumps and fans calculation *is* included in the fuel poverty methodology.

The full calculation for pump and fan consumption is covered in Annex 5.

5.2.4 Cooking[53]

The required energy consumption calculation for cooking is again intended to represent what is considered to be 'typical' consumption for a household in England, taking into consideration the number of people in the home (with large households assumed to consume more energy through cooking) and the type of cooker owned.

Different calculations are made depending on whether a modelled household owns an electric-only cooker, a gas-only cooker, or a mixed gas-and-electric cooker (e.g. gas hobs and an electric oven).

There are also different figures for 'normal' and 'large' cookers. However, when used as part of the fuel poverty methodology, only 'normal' sized cookers are accounted for. According to BRE, this is likely to be because large cookers are relatively unusual in the housing stock (it could be interpreted that large cookers are therefore de factor considered to be a luxury, not a 'basic need'), and fuel poor households are assumed to be less likely to own larger, more expensive cookers and so not including them is unlikely to influence the accuracy of the model.

Like hot water, the calculations for cooking provide another example of where changes have been made over time to reflect indicators of shifting levels of actual consumption. In BREDEM-2012, the figures of 'typical' energy consumption for the different cooker types is around 30-40% lower than the previous 2001 iteration of BREDEM (BREDEM-12). This is because, in developing BREDEM-2012, BRE had more up-to-date evidence that consumption levels for electric-only cookers had fallen by this amount, compared to the previous data they had been using that dated back to 1980s. Although they did not have comparable data for the actual levels of energy consumption of gas-only cookers, it was thought sensible to assume that the consumption for these had also fallen by 30-40%.

[53] The equation for calculating cooking energy consumption use appears to be differ between the BREDEM-2012 Technical Report and DECC's 2014 Fuel Poverty User Manual. However this difference is due to different units of measurement being used, with kWh used in the BRE report and giga-joules used in the DECC User Manual.

The full calculations for cooking energy consumption are covered in Annex 5.

6 Evaluations of the approach to calculating required non-heating energy use

Section 5 demonstrated how different methods are used to calculate the required energy consumption for different energy uses. For space heating and hot water, a standard of energy service is first specified before calculating the energy consumption necessary to meet this standard; for other uses, a service standard is not specified. There are also different principles of need evident. For space heating, the standard of service is defined by some form of 'expert' knowledge of what constitutes healthy room temperatures. All other energy uses attempt to follow what is 'typical' actual consumption in England, such that need is equivalent to normal consumption.

There are also important differences regarding the types of differentiation that are taken into account when calculating the 'required' energy consumption of different types of households – illustrated in full in Annex 4. The space heating calculations allow for differentiation in the time people spend at home, in whether a household is 'under occupied', and in insulation levels of different houses; likewise, the hot water calculations allow for boiler efficiency and hot water pipe lagging to be considered. In contrast, several of the non-heating calculations (with the exception of, at a basic level, lighting) only account for number of occupants and the house's total floor area. As already noted, this is partly a *result* of the type of calculation method adopted – when using the 'typical consumption' method, it is more difficult to incorporate differences between households in terms of energy efficiency.

Despite this rather complex and arguably inconsistent situation, there has been little published evaluation of the current approach to calculating non-heating consumption in the fuel poverty model – mirroring the relatively low level of attention non-heating energy uses receive in fuel poverty policy and discourse more generally.

The only report that we could find providing such an evaluation, and consideration of alternatives, is the aforementioned 2005 Peer Review by Sefton and Chesshire.[54] In this, the authors expressed concerns about whether it was appropriate to use actual 'typical consumption' as the marker of 'required consumption' in the non-heating elements of the fuel poverty model. They propose an alternative: first defining 'standards of energy service' for 'key appliances' (although they do not specify what these key appliances would be, nor how the 'standards' for each of them would be decided upon and defined), before then calculating the energy consumption required to achieve these standards. This latter stage would incorporate data on the typical energy efficiency of key appliances across different sections of the population. In short, this would be the same approach as currently utilised when calculating the energy requirements of space heating and hot water.

The Peer Review identified what it considered to be two limitations in the current approach to calculating the required energy consumption for lights, appliances, pumps and fans, and cooking.

i. *Accuracy of current calculations of numbers of people in fuel poverty:* As noted earlier in this report, Sefton and Chesshire argue that the current 'typical consumption' approach does not easily allow for differences between households in the efficiency of their non-heating energy technologies to be accounted for. They see this as a major weakness, impacting on the relative accuracy of the fuel poverty model, both in terms of the total number of people in fuel poverty and also the vulnerability of different groups to the problem. One reason for this is the types of appliances different types of households may be likely to own – as Sefton and Chesshire state: *"If, as seems likely, low income households tend to own older and less efficient appliances, then they would need to spend more to achieve a given standard of non-heating services, but this is not currently reflected in the fuel poverty statistics."*[55] Their assertion that low income households tend to own less efficient appliances is backed up by a small amount of evidence. The 2011 Energy Follow-up Survey found that older people tend to have older fridges and freezers, with older cold appliances generally much less efficient than the most recent models.[56] Meanwhile, some 1997 research by Brenda Boardman and colleagues found that, of those they surveyed, less than 50 per cent of low-income households brought their cold appliances as new, with the majority purchasing old, second-hand machines that were often faulty.[57] Boardman later noted in 2010 that there is no particular reason to assume that this situation had changed.[58]

ii. *Revealing the impact of policy support measures*: Sefton and Chesshire argue that, *because* the current method for calculating the required energy for lights, appliances and cooking does not allow for differences in technological efficiency to be accounted for in the fuel poverty model, this also means that the model is likely to be relatively ineffective at *"picking up the impact on fuel poverty of policies designed to influence the non-heating components of domestic fuel consumption."*[59] Such improvements will not have an impact on fuel poverty calculations until the lights and appliances algorithms are updated; however, even then the impact will only be indirect *"in so far as this affects the average use across all households"*, and therefore *"the benefits of more targeted schemes aimed at low income households will not show up very clearly, if at all"*.[60]

[54] Sefton, T. and Chesshire, J. (2005) *Peer Review of the Methodology for Calculating the Number of Households in Fuel Poverty in England: Final Report to DTI and DEFRA.* London: DEFRA/DTI.

[55] Sefton and Chesshire (2005), p.38

[56] BRE (2013) *Energy Follow-up Survey, 2011: Report 9: Domestic appliances, cooking & cooling equipment*. Watford: BRE, p.12

[57] Boardman, B., Lane, K., Hinnells, M., Banks, N., Milne, G., Goodwin, A. and Fawcett, T. (1997) *Transforming the UK Cold Market*. Oxford: DECADE Project, Environmental Change Institute, University of Oxford.

[58] Boardman, B. (2010) *Fixing Fuel Poverty: Challenges and Solutions.* London: Earthscan, p.113.

[59] Sefton and Chesshire (2005) p.16

[60] Sefton and Chesshire (2005) p.38

In advocating that it would be desirable to adopt an alternative approach based on defining standards of service for non-heating energy uses, the Peer Review identifies what it considers to be three strengths of such a method:

i. It would be better at picking up the impact of targeted policies aimed at increasing appliance efficiency for those on low incomes
ii. It would be more consistent with the treatment of heating costs
iii. It would be more *"conceptually sound"*[61]

In order for a standard to be utilised, Sefton and Chesshire note that much more detailed data collection from the English Housing Condition Survey (EHCS)[62] would be necessary, involving data collection on the energy efficiency of lighting and what they term 'key appliances.' They suggest that this would have implications for the design of the EHCS, potentially meaning a longer questionnaire and a greater required level of expertise for surveyors and interviewers. They note that the government of the time (specifically, the then Office of the Deputy Prime Minister) would be likely to resist such changes, since they had already sought to shorten the EHCS questions to both increase response rate and cut costs. They also recognise that adopting standards for non-heating energy uses would *"significantly add to the complexity to an already complex model"*.[63]

As noted, Sefton and Chesshire's Peer Review appears to be the only place where potential alternatives to the current method of calculating the energy required for non-heating purposes – such as the standards of service approach – has been discussed or proposed. The issue was not mentioned in the in either the Interim or the Full Report of the 2011-2012 Fuel Poverty Review, nor does it appear to have been discussed in any subsequent DECC reports. It is also notable that whilst many of the recommendations made by the Sefton and Chesshire Peer Review were adopted into the official fuel poverty methodology,[64] the proposal to set standards of service to calculate non-heating energy consumption was not. The reasons for this exclusion are unclear, and have do not appear to have been publically stated. It may be that the pragmatic considerations that Sefton and Chesshire raised – around the requirement of new data from the EHCS, or the additional complexity required in the BREDEM model – provide the main explanation for why their discussion and set of proposals was taken no further.

[61] Ibid., 2005, p.38
[62] Now known as the English Housing Survey (EHS)
[63] Ibid., p.39
[64] Hills Review Interim Report, p.101

Annex 1: Analysis of reference to energy uses in recent policy documents

Document	Year	Heat/ing	Warm/ Warmth	Non-heating	Light/s/ lighting	Cook/ing	Appliance/s	Water heating/ hot water/ showering
Fuel poverty: changing the framework for measurement	2012	23	26	0	1	1	2	2
Fuel poverty: changing the framework for measurement: Government Response	2013	4	6	0	0	0	0	0
Fuel Poverty: A framework for future action	2013	64	19	0	0	0	2	0
Cutting the costs of keeping warm: A new fuel poverty strategy for England	2014	92	72	0	3	0	0	3
Annual Fuel Poverty Statistics Report	2014	54	17	0	5	3	4	4

Annex 2: Summary of current and recent policy measures and energy uses targeted

Scheme	Time active	Eligible population	Type of assistance	Energy uses targeted
ECO Affordable Warmth Obligation	2013-present	Those claiming certain income-related benefits	Grants for: boiler replacement/ repair; house insulation; any other measure that will result in a heating saving	Space heating; water heating
ECO Carbon Savings Communities Obligation	2013-present	Those living within specified localities of low income	Grants for: house insulation; district heating	Space heating; water heating
Warm Front	2001-2013	Those claiming certain income-related benefits	Grants for: house insulation; hot water tank insulation; boiler replacement; draft proofing	Space heating; water heating
CERT	2008-2012	Any customers of each energy supplier, but 40% of energy savings targeted at over-70s or claiming certain income-related benefits	Originally, grants for: Any action that would result in an energy saving and so a reduction in carbon emissions. After June 2010, 68% of measures had to be professionally installed home insulation.	Originally focused on a range, covering both space heating and non-space-heating. After 2010 changes, more specific focus on space heating
CESP	2009-2012	Those living within specified localities of low income	Grants for: insulation; glazing; boiler replacement; draft proofing; heat pumps; micro-generation; heating controls; district heating; home energy advice	Mostly space heating and water heating. Some focus on non-heating uses through the provision of home energy advice and micro-generation
Cold Weather Payment	1994-present	Those claiming certain income-related benefits	Income support payment (£25 for each 7-day period of cold weather)	N/A
Winter Fuel Payment	1997-present	Those of pensionable age	Income support payment (One-off payment of £100-£300 each winter)	N/A
Warm Home Discount	April 2011-March 2015	Older people on low incomes OR a broader group defined by the energy supplier as vulnerable	Rebate on electricity bill (£120-£140)	N/A

Annex 3: The four heating regimes used in the fuel poverty model when calculating the energy consumption required for space heating

The standard heating regime – representing adults who are not home all day on weekdays, and whose homes are not under-occupied

	Details of STANDARD heating regime
Heating pattern	Weekday 9 hours of heating Weekend 16 hours of heating
Heating extent	Whole house
Demand temperature	Primary living zone 21oC Secondary living zone 18oC

The full heating regime – representing adults who are normally at home all day on weekdays, and whose homes are not under-occupied

	Details of FULL heating regime
Heating pattern	Weekday 16 hours of heating Weekend 16 hours of heating
Heating extent	Whole house
Demand temperature	Primary living zone 21oC Secondary living zone 18oC

The standard heating regime – representing adults who are not home all day on weekdays, and whose homes *are* under-occupied

	Details of PARTIAL STANDARD heating regime
Heating pattern	Weekday 9 hours of heating Weekend 16 hours of heating
Heating extent	Half house
Demand temperature	Primary living zone 21oC Secondary living zone 18oC

The full heating regime – representing adults who are normally at home all day on weekdays, and whose homes *are* under-occupied

	Details of PARTIAL FULL heating regime
Heating pattern	Weekday 16 hours of heating Weekend 16 hours of heating
Heating extent	Half house
Demand temperature	Primary living zone 21oC Secondary living zone 18oC

Annex 4: How the different required energy calculations incorporate variation across households for different energy uses

Energy use category	Variation between households that is allowed for			
	Household size and/or floor area	Amount of time home occupied	Efficiency of technologies and/or building	Geographical location
Heating	✓	✓	✓	✓
Lighting	✓	X	*Partly*	✓
Appliances	✓	X	X	X
Pumps and Fans	X	X	✓	X
Cooking	✓	X	X	X
Hot water	✓	X	✓	✓

Annex 5: Full details on calculation of required energy consumption for non-space heating purposes

This Annex provides the full calculations for deriving 'required' energy consumption for each of the non-space-heating elements included in the fuel poverty methodology. The main source of these details is BRE's report (available online) '*BREDEM 2012 – A technical description of the BRE Domestic Energy Model*', with some additional clarification provided by a member of BRE via a face-to-face interview.

Lighting energy consumption

Symbol	Data item	Units
TFA	Total floor area of dwelling	m2
N	Number of occupants	Occupants
E_B	Lighting energy basic requirement	kWh/yr
E_L'	Initial annual lighting energy	kWh/yr
$E_{L,M}$	Lighting energy used each month	kWh/month
E_L	Final annual lighting energy	kWh/yr
C_1	Low energy lighting correction factor	Dimensionless
C_2	Daylight correction factor	Dimensionless
$L_{\%}$	Proportion of energy provided by low energy lights	Percentage
G_{DL}	Daylight availability	Dimensionless
A_W	Total window area	m2
g_L	Light transmission factor	Dimensionless
Fr	Frame factor	Dimensionless
Z_L	Light access factor	Dimensionless
m	Month number	Dimensionless
n_m	Number of days in month	Days

A. First, the 'lighting energy basic requirement' is calculated, taking into account total floor area and number of occupants

$$E_B = 59.73 \times (TFA \times N)^{0.4714}$$

B. The 'low energy lighting correction factor', which aims to ensure the final figure for required energy takes into account the proliferation of low energy lighting in the UK, is then calculated

$$C_1 = 1 - 0.5 \times L_{\%}$$

C. Daylight correction factor is then calculated, taking into account the total window area of the home, the type of window glazing, the type of window frame, and whether there is any shading over the home. This assumes that homes which receive less daylight will use/require more electrical lighting

$G_{DL} = \sum (0.9 \times A_W \times g_L \times Fr \times Z_L) / TFA$ *(summing over all the windows)*
If $G_{DL} \leq 0.095$, then $C_2 = 52.2 \times G_{DL}^2 - 9.94 \times G_{DL} + 1.433$
If $G_{DL} > 0.095$, then $C_2 = 0.96$

D. The lighting energy basic requirement is then corrected to take into account the figures on low energy lighting and daylight

$$E_L' = E_B \times C_1 \times C_2$$

E. This figure is then corrected to account for different lighting usage in different months. This gives individual figures for each month of the year

$$E_{L,m} = E_L' \times [1 + 0.5 \times \cos(2\pi(m - 0.2)/12)] \times n_m/365i$$

F. The individual monthly figures are then summed together to give the final annual lighting energy requirement – this figure is input into the fuel poverty model

$E_L = \sum E_{L,m}$ *(summing over all months)*

Appliance energy consumption

A. The initial annual appliance energy takes into account the total floor area of the property and the number of people – the basic assumption is that the bigger the property and the more people, the bigger the consumption:

$E_A' = 184.8 \times (TFA \times N)^{0.4714}$

Symbol	Data item	Units
$E_{A'}$	Initial annual appliance energy	kWh/yr
$E_{A,m}$	Appliance energy used each month	kWh/month
E_A	Final annual appliance energy	kWh/yr
n_m	Number of days in month	Days
m	Month number	Dimensionless

B. This figure is then corrected to account for different appliance usage in different months. This gives individual figures for each month of the year:

$E_{A,m} = E_A' \times [1 + 0.157 \times \cos(2\pi(m - 1.78)/12)] \times n_m/365$[ii]

C. The individual monthly figures are then summed together to give the final annual appliance energy requirement – this figure is input into the fuel poverty model:

$E_A = \sum E_{A,m}$ (summing over all the months)

Pump and fan energy consumption

$E_{p\&f} = \sum$applicable items from Table 1

Table 1: Energy requirements of pumps and fans

Equipment	kWh/yr
Heating system	
Standard central heating pump	120
Standard central heating pump (no room thermostat)	156
Low energy central heating pump	30
Low energy central heating pump (no room thermostat)	39
Oil boiler (fan flue and pump supplying oil to boiler)	100
Gas boiler or heat pump flue fan (if fan assisted)	45
Warm air heating system fans	$0.6 \times V_T$
Keep hot facility of combi boiler	
Keep hot facility controlled by time-clock	600
Keep hot facility not controlled by time-clock	900
Ventilation system	
Mechanical extract ventilation fans	$SFP \times 1.22 \times V_T$
Balanced whole-house mechanical ventilation fans	$SFP \times 2.44 \times n_{mech} \times V_T$
Positive input ventilation from loft space	0
Positive input ventilation from outside	$SFP \times 1.22 \times V_T$
Intermittent extract fans	28 per fan
Solar water heating pump	
Powered by mains electricity	50
Powered by PV	0

Symbol	Data item	Units
$E_{p\&f}$	Energy for pumps and fans	kWh/yr
SFP	Specific ventilation fan power	W/(l/s)
V_T	Internal volume of dwelling	m3

Cooking energy consumption (annual)

A. The initial cooking calculation takes into consideration type of cooker (using the predefined figures shown in Table 2) and number of occupants within the household, with greater consumption assumed for greater numbers of occupants

$E_{C1} = E_{C1A} + (E_{C1B} \times N)$

B. There is a second calculation, to account for households that have cookers that use both gas and electric (e.g. gas hobs and electric oven). If the household has a cooker that uses only one type of fuel, the numbers input into this equation are 0 (see Table 2)

$E_{C2} = E_{C2A} + (E_{C2B} \times N)$

Symbol	Data item	Units
E_{C1}	Annual cooking energy (fuel 1)	kWh/yr
E_{C1A}	Cooker type coefficient (fuel 1)	kWh/yr
E_{C1B}	Cooker type coefficient per-person (fuel 1)	kWh/yr p.p.
E_{C2}	Annual cooking energy (fuel 2)	kWh/yr
E_{C2A}	Cooker type coefficient (fuel 2)	kWh/yr
E_{C2B}	Cooker type coefficient per-person (fuel 2)	kWh/yr p.p.
N	Number of occupants	Occupants

Table 2 Cooking type coefficients

Cooker type	E_{C1A}	E_{C1B}	E_{C2A}	E_{C2B}
Normal size cooker: electric	275	55	0	0
Normal size cooker: gas	481	96	0	0
Normal size cooker: electric/gas	138	28	241	48

Nb. There are also calculations in BRE for monthly consumption and for ranges, but these are not used in the fuel poverty methodology

Nb. There are also calculations for large cookers, but these are not included in the fuel poverty methodology

Energy required to heat water

Symbol	Data item	Units
n_{shower}	Number of showers per day	Showers/day
N	Number of occupants	Occupants
$V_{d,shower}$	Daily hot water requirement for showers	Litres/day
V_{PS}	Hot water use per shower	Litres
n_{bath}	Number of baths per day	Baths/day
$V_{d,bath}$	Daily hot water requirements for baths	Litres/day
$V_{d,other}$	Daily hot water requirements for other uses	Litres/day
$V_{d,ave}$	Average daily hot water requirement	Litres/day
$V_{d,m}$	Daily hot water requirement in month m	Litres/day
f_{hw}	Monthly hot water use factor	Dimensionless
$Q_{HW,m}$	Monthly rise in temperature required	^{o}C
n_m	Monthly energy content of heated water	kWh/month
T_m	Number of days in month, m	Days
Q_{HW}	Annual energy content of heated water	kWh/yr

A. The first step is to calculate the number of showers taken per day by each household. If the actual number is known then this figure should be used; however when doing stock modelling like the fuel poverty model the number is assumed using the following equation:
$n_{shower} = 0.45N + 0.65$

B. The daily hot water requirements of showering is then calculated, taking into account both the number of showers per day but also the shower flow rate:
$V_{d,shower} = n_{shower} \times V_{PS}$

C. The number of baths per day is then calculated. For stock modelling, this is done through one of two equations:
If a shower is assumed to also be present: $n_{bath} = 0.13N + 0.19$
If no shower is assumed to be present: $n_{bath} = 0.35N + 0.5$
Nb. The assumption here is that if a household has a shower present, then it will take fewer baths

D. The equation then calculates the daily hot water requirements baths, accounting for the number taken per day:
$V_{d,bath} = n_{bath} \times 50.8$

E. An allowance for hot water for required for 'other uses' is then worked out:
$V_{d,other} = 9.8N + 14$

F. These different allowances (for showers, baths, and other uses) are summed together to give the 'average daily hot water requirement' in litres:
$V_{d,ave} = V_{d,shower} + V_{d,bath} + V_{d,other}$

G. The daily hot water requirement for *each month* of the year is then worked out. This factors in a monthly 'hot water use factor', using figures set in the BREDEM Technical Report, which attempts to account for differences in the amount of how water people tend to use over the course of the year – it is assumed that people consume more hot water in the winter months:
$V_{d,m} = V_{d,ave} \times f_{hw}$

H. The monthly *energy requirement* of this heated water is then calculated. This takes into consideration both the number of days in each month, and that during colder months more energy is required to heat water to the same temperature (figures for these aspects are again provided in the BREDEM Technical Report).
$Q_{HW,m} = 4.19 \times V_{d,m} \times n_m \times \Delta T_m / 3600$

I. The final figure for the annual energy requirements of heating water is derived by summing together the separate monthly figures calculated in step H:
$Q_{HW} = \sum Q_{HW,m}$

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