Fuel Poverty Methodology Documentation

First published July 2006
Minor Revision made September 2006

bre dti defra
Department for Environment Food and Rural Affairs

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Introduction

Purpose of the Documentation

This document describes the methodology used to calculate the 2003 fuel poverty figures for England. It is the result of a work stream launched following an independent review of the fuel poverty calculation methodology[1].

The main body of the document is divided into three sections each describing one of the three main components of the fuel poverty calculation methodology; income, fuel prices and energy consumption.

Background

The key data source used to derive estimates of fuel poverty in England is the English House Condition Survey (EHCS). This survey provides information on the changing condition and composition of the housing stock and the characteristics of the households living in different types of dwelling.

Originally carried out every five years until 2001, the EHCS now operates on a continuous format in which a population of approximately 8,000 dwellings is sampled each year. For the majority of analyses, including the monitoring of fuel poverty in England, two years' datasets are combined to give ~16,000 dwellings/households.

The survey comprises three components; an interview survey, a physical survey and a market value survey. To calculate households that are fuel poor (defined as those which would need to spend more than 10% of their income on all fuel use whilst maintaining an adequate standard of warmth), household level information on fuel costs and incomes are required.

For each case on the EHCS, a 'fuel poverty ratio' is calculated. This calculation has three components – energy prices (unit and standing charges), fuel consumption and income. The equation takes the following form:

$$\text{Fuel poverty ratio} = \frac{\sum(\text{Unit Fuel Price} \times \text{Fuel Consumption}) + \sum \text{Standing Charge}}{\text{Income}}$$

Where for each household the following applies:

i) The unit fuel price (£/GJ) is applied to each fuel type
ii) Fuel consumption (GJ) is the energy use for each fuel type
iii) Standing charges (£) are applied where applicable for each fuel type and
iv) Income (£) is the annual income of the whole household.

Note that for every household all applicable use and cost values are summed for each fuel type.

If the fuel poverty ratio is greater than 0.1 (i.e. a household spends more than 10% of their income on fuel) then the household is considered to be fuel poor.

Income

A list of the acronyms used in the description of the income model can be found in appendix A.

Development of the Income Model

The original version of the Fuel Poverty Income Model, known as the 1996 Methodology, was used to calculate the published fuel poverty figures for 1996, 1998 and 2001. Small modifications were made as a result of improvements in the treatment of missing data and changes in the benefit and tax system.

In 2004, the Department of Trade and Industry (DTI) commissioned a consultation to discuss changes proposed by the Building Research Establishment (BRE) to the fuel poverty methodology. This resulted in three significant changes to the modelling of household incomes, all of which came about due to additional information being collected in the EHCS interview survey. The first was to do with the treatment of income from other members of a household and the second and third were to do with council tax and council tax benefit. This updated method, known as the 2001 Methodology, is the current methodology and has been used to calculate the fuel poverty figures for 2003 and was also used to re-calculate the figures for 2001 in order to assess the impact of the changes on the fuel poverty statistics.

Modelling Process

Modelling Steps

In modelling incomes for fuel poverty, two definitions have been adopted:

i) "Basic income" excludes income related directly to housing.

ii) "Full income", used for targets, includes income related directly to housing (i.e. Housing Benefit, Income Support for Mortgage Interest (ISMI), Mortgage Payment Protection Insurance (MPPI), Council Tax Benefit (CTB) and the payment of council tax).

For both definitions it is the income, net of income tax and national insurance, of the whole household. That is the income of the Household Reference Person (HRP) and any partner, plus any other adult member.

There are three major steps involved in modelling household incomes for fuel poverty. First, the Primary Benefit Unit (PBU) Income is calculated for the HRP and partner in each household. Next, the Fuel Poverty Basic Income is modelled for each household and from this, the Fuel Poverty Full Income is modelled. The specific procedures involved in each step are discussed in detail in the following sections. The diagram in appendix B shows the outline of the steps involved in the process.

The fuel poverty income model is coded in SPSS® syntax, consisting of separate programs for all the components, which are run in sequence through the SPSS® program.

Data Sources

The EHCS collects detailed information about the income of the HRP and any partner from different sources (wages, pensions, benefits, savings and investments and other sources e.g. rent from property). Respondents are asked separately about each source and which, if any, state benefits they receive. This information is

collated and modelled to produce total net income for the primary benefit unit (HRP and any partner/spouse). Less detailed information is collected from the respondent (who is always in the primary benefit unit) about the income of any additional benefit units in the household. The EHCS also collects information on housing and council tax benefit, council tax bands, ISMI and MPPI.

Missing Data

The EHCS income model assumes that the details given by the respondent are correct unless they are totally implausible. There is usually a proportion of cases in which data on incomes is either refused or unknown and for these cases a method of imputation is required. The imputation methods used are described in detail in the relevant section of this documentation. Table 1 summarises the type and method of imputations carried out.

Type of income	Type of missing data	Method of imputation
Private incomes		
Self-employed	Amounts missing	New Earnings Survey
Regular employment	Amounts missing	New Earnings Survey
Government scheme	Amounts missing	Sample mean
Occupational pension	Amounts missing	Sample mean
Private pension	Amounts missing	Sample mean
Other sources	Amounts missing	None
Other work	Amounts missing	None
Total private income	If answered don't know or refused	Sample mean imputed at later stage
	to any private income question	
State benefits	Benefits received are refused or d/k.	Sample mean imputed at later stage
Income support JSA* WFTC State pension Child benefit Working tax credit** Child tax credit** Maternity allowance Widows pension War disablement pension Severe disability allowance Industrial injuries allowance Carers allowance DLA (mobility component) DLA (care component) Disabled persons tax credit Statutory sick pay Disability premium with IS/HB	Benefit amount is refused or d/k	Theoretical amounts modelled
Attendance allowance	Benefit amount is refused or d/k	Middle rate modelled
Incapacity benefit	Benefit amount is refused or d/k	Incapacity benefit modelled at lower rate
Other disability benefit	Benefit amount is refused or d/k	Theoretical amount of DLA (mobility) modelled
PBU income	Net household income missing	Mean sample income imputed
Low income imputed	If income is below minimum income guarantee:	If any benefits received, basic IS imputed.
		If no benefits received, sample mean income imputed.
Savings	Amount of savings refused/don't know	Imputed using CHAID
Additional benefit units	Gross income of ABUs missing	If working, given NES means based on sex age and working status
		If not working, given theoretical income support entitlement
WFP	No information on whether hhold receives WFP	Given to all 60 and over hholds – eligible for different amounts depending on number and age of over 60s
Housing benefit	No information on how much hhold receives	Theoretical amount calculated following Zebedee et al, 2004
	Rental amounts missing	Impute rents using ODPM data
ISMI	No amount given	Imputed using mortgage information or from sample mean
MPPI	No information given as to amount	Imputed from median monthly mortgage payment of those receiving MPPI
Council tax benefit	Amount of CTB	Theoretical amount calculated following Zebedee et al, 2004

Table 1: Imputation procedures

*Income-based JSA modelled; no information on contribution based. Actual amount received is dependent on savings and partner's working hours but quality of data is not good enough to characterise this. Disability premium not modelled.
**WTC and CTC brought in in 2003. May be paid in wages but no information available. Currently it is assumed it is not. Disability premiums not included. Child care element not modelled for WTC.

EHCS Primary Benefit Unit (PBU) Income Model

The PBU Income model starts with three data files obtained from the EHCS interview survey; People.sav, Income.sav and Employment.sav. These files are sorted by the EHCS key code (aacode), initial checks are performed and some preliminary recoding is done to the relationship of each person to the HRP (required due to the way that the survey form is set up). A series of indicators about the household are created - age, sex, marital status, working status of HRP and any partner and the ages of any dependent children. Basic checks are done on the input files to ensure that key variables such as age and sex are complete and plausible for all cases and that cases over 16 have marriage and employment status and no cases have more than one partner.

A fourth file, Disability.sav, is used to create two variables, the number of people registered disabled and the number of people who are disabled but not registered. Disabled people in other benefit units are then selected out as their circumstances do not influence the HRP/partner's income. The household indicators created are used to compute theoretical entitlement to benefits. Weekly amounts for income support, JSA, state retirement pension (standard amounts are used which don't include any SERPS), incapacity benefit and child benefit are calculated and rounded up to an annual amount. Data for the theoretical benefit entitlements are obtained from information provided by the Department of Work and Pensions (DWP) for the corresponding year.

Income From Private Sources

Initial checks are made to verify that the Boolean responses to the private income questions correspond to responses concerning the amount of income from that source. Separate programs are used to calculate the annual income from regular employment, self-employment, government schemes, occupational pensions, private pensions, other work and other sources. Income from private sources is coded in bands in the EHCS survey and either a gross or net amount or both is provided. In the calculations, incomes are set at the mid-point of the band.

The programs carry out various checks and for regular and self-employment incomes, cases that look implausible are flagged for further checking (gross or net earnings are greater than £100,000 or greater than £30,000 if tenure is LA/RSL or unknown; part-time earnings over £30,000; or if income is estimated). For cases in which the amount of income from a private source is missing, amounts are imputed according to the methods shown in table 1. For regular and self-employed income, the rule used for imputing amounts for part-time employment is that if the hours worked are less than or equal to 15 per week the amount imputed is one-third of the full-time amount. For more than 15 hours per week, the amount is two-thirds of the full-time amount. The default is full-time if the variable is missing or unknown. The amounts imputed are the same for regular and self-employment. No imputations are performed for income from other sources or other work as the amounts are too variable to be reliable. Incomes for these cases are imputed later using the group mean.

Information on all private sources is combined. Where net amounts are given for income from private sources, the gross amount for that source is approximated by increasing the net amount by 20% (unless the combined net and gross income is less than the tax threshold of £4615, when it is assumed that no tax is paid and the net amount is set to the gross amount) and the total gross private income for the

HRP and any partner is calculated. This is a requirement for the deductions sub-routine because the amount of tax payable will be underestimated (and therefore the income overestimated) if part of taxable income is given as net and part as gross. We cannot simply calculate the tax on the gross part and then add the gross-taxed to the net as the rate of tax is dependent on income thresholds, set for all taxable income. A number of flags are created indicating the nature and extent of any imputation. If incomes from other work or other sources are missing, the total income is set to missing.

Income From State Benefits

The EHCS interview survey asks about benefits paid to the HRP or their partner and the period of payment. It does not check if the benefit is for one or both people in a couple, so this needs to be estimated for the purposes of tax deductions. Combining benefits is an important aspect of the model. Households often receive more than one benefit and, if one of these benefits is means tested, it may determine the value of other benefits. Typically, respondents know the amount of income they receive from benefits but do not necessarily know exactly which benefits they receive. For cases in which data is missing or totally implausible, benefit rates are applied using the prescribed rates for the correct period.

Four key variables are created: total taxable benefit income for the head of household (HOH), total non-taxable benefit income for HOH, total taxable benefit income for partner, total non-taxable benefit income for partner. The HOH is used because the taxation system treats the man in a couple as being the head of the household and can therefore be different from the HRP.

Deductions

The private and benefit income is added together, distinguishing between taxable and non-taxable. It uses the 3 key variables of whether self-employed, whether over state retirement age for the HRP and partner and whether the HRP or partner makes a contribution into their employer's occupational pension scheme, to calculate the amount of National Insurance payable (Class 1, 2 and 4 contributions). The programme then calculates the personal tax allowances for the HRP and partner and calculates the total amount of tax payable. It then sorts out if the HRP or partner is entitled to any of the other allowances restricted at 10% (married man's, married age and additional personal allowances) and recalculates tax payable. It then computes

$$\text{Net Income} = \text{Non Taxable Income} + \left(\text{Taxable Income} - \left(\text{National Insurance} + \text{Income Tax}\right)\right)$$

total net income for HRP and partner separately where:

It adds together the HRP and partner's incomes. If one is missing and both should have a valid value even if it is zero, then it is set to missing.

Imputing Missing Income Data

At this stage there are two scenarios in which the PBU income could still be missing:

i) If income amounts from the private sources 'other work' or 'other sources' are missing, or if the respondent answered 'don't know' 'or 'refused' to income from private sources and benefits.

ii) If missing income from state benefits is imputed using theoretical amounts which are calculated using the assessed income of the HRP and partner; and this is missing.

Two programs are used for imputing missing income data. The first deals with income data that is either zero or very low. If household income is less than the minimum, defined as basic income support, it is changed. Where the household receives any of the main state benefits (excluding child benefit) their income is pegged to the basic IS amount (plus any disability premiums if they qualify). Where they do not receive any state benefits then it is assumed that some component of their income is missing and the whole lot is set to missing and imputed in the next program. A flag is created to identify cases which are changed and the original values are kept for later checking.

The second program uses the mean income of key groups from the weighted EHCS dataset to impute missing household income. The employment status and SEG group of both HRP and partner is used to create a 'combined' flag for the household.

Income From Savings

A question about savings and money invested is asked of the interviewee in the interview survey. Approximately 5% of the data obtained is missing, perhaps due to the unwillingness of householders to divulge this personal information. A method based on CHAID analysis is used to estimate the savings for each household. The data collected on savings from the interview survey is used as the dependent variable in the analysis.

The predictor variables used for estimating savings are: tenure, age of HRP, number of jobs (HRP plus partner), highest educational qualification, single householder or with partner, sex of HRP, manual or non-manual occupation, pension, benefits (whether the HRP gets any means-tested benefits), dwelling type and dwelling market value. Once all the cases have a savings band, the midpoint is taken as their savings amount. The income received from these savings is then calculated using an interest rate of 3% net of tax.

Output

The final PBU income variable (hhincx) is created by adding the savings income to the HRP and partner's net income from private sources and benefits.

Fuel Poverty Basic Income Model

Additional Benefit Units.

The fuel poverty Basic Income measure is the household income, including income from additional benefit units (ABUs), for example a grown-up child living with their parents or two or more people sharing a house. In addition, the winter fuel payment (WFP), made annually to those eligible is included in the FP Basic Income.

In the 1996 methodology, income from ABUs was modelled using a correction factor based on the FES survey. The 2001 methodology uses data collected during the interview survey. The number of additional benefit units in the household is derived by the CAPI program during the interview and questions are asked for each ABU as to whether they receive any of the main benefits and the total gross earnings (income plus benefits) for each ABU. Although very little data regarding the benefits is unknown (~4% of cases with ABUs), approximately 37% of the gross income variable is missing. This missing income data is imputed using NES (now known as ASHE) data (if the ABU is working), based on sex, age and working hours (incomes for part

time workers are imputed at a rate of half those of full time workers) or from the theoretical entitlement to income support for those cases not working.

Winter Fuel Payments (WFP)

The Winter Fuel Payment, introduced in 1998, is a payment given once a year to help older people with their heating bills. It is available to all households with at least one resident aged 60 years or over and is paid automatically to an eligible person who receives a state benefit (other than housing benefit, council tax benefit or child benefit). Those who do not receive benefits have to claim the payment. No question is asked in the EHCS survey as to whether anyone in a household receives WFP. In the FP Basic Income model, the WFP is given to anyone aged 60 or over (additional amounts are payable to those aged 80 or over and in 2004 a one-off payment was also available to those aged 70 or over).

Output

The Fuel Poverty Basic Income variable, (fpbasinc) is created by adding the income from the ABUs in a household and the winter fuel payments to the PBU income variable (hhincx).

Fuel Poverty Full Income Model

The Fuel Poverty Full Income measure (FP Full Income) is the final output of the income model and is the measure used in the calculation of the Fuel Poverty Indicator used for targeting. Income/outgoings relating to housing costs are dealt with in this final step.

Income From Housing Benefit.

The purpose of the housing benefit (HB) scheme is to help people on low incomes pay their rent (families who own their own homes may have their mortgage interest payments met through income support – see below). People on IS, income-based JSA or the guarantee credit element of the pension credit are automatically entitled to the full level of HB. For other claimants, the amount of HB payable depends upon their income in much the same way as for IS or income-based JSA.

Income From ISMI

Income Support Mortgage Interest (ISMI) is an additional payment of interest on a mortgage. The criteria for receiving ISMI are 1) that the homeowner receives either income support or JSA, 2) that there is an outstanding mortgage on the property, 3) that the owner of the property lives in it and 4) that the claimant has savings totalling less than £8,000 pounds. Monthly mortgage repayments for ISMI are calculated in the income model using the following rules:

- Households receiving ISMI that have provided a monthly amount are assigned this amount.
- Households that receive ISMI but have given no amount have their payments calculated if they have provided sufficient mortgage information. If no term of mortgage is provided it is assumed to be 25 years. The monthly interest payments are calculated for the outstanding loan amount using the average interest rate of the top 20 lenders as reported by the ONS.
- Households that receive ISMI but have given no amount and have insufficient mortgage information are assigned the median monthly ISMI amount from those with known amounts.

Income From MPPI

If the owner and HRP or partner are not working, the question is asked in the interview survey as to whether any contributions to the mortgage payments are received under an MPPI policy. No amount for the payment received is requested but the respondent answers as to whether the payment covers the full amount or part amount of the mortgage. Amounts for MPPI income are imputed using the median monthly mortgage payment of those cases who receive MPPI. Minimum and maximum amounts are calculated in the same manner as for ISMI.

Income From Council Tax Benefit (CTB)

The interview survey asks whether council tax benefit is received by the HRP or partner. The actual amounts received are modelled by applying the standard means test for income disregards and applicable amounts, with the addition of premiums for number of children, age and whether the dwelling contains a family. These modelled amounts are used unless there has been income imputation, in which case the respondent's answer is taken.

Council Tax Deduction

Since 2002/03, the council tax band for each dwelling has been collected through the Market Value Survey (MVS). The amount of council tax paid by the household is therefore modelled using the council tax band of the dwelling and information about charges in the relevant local authority area. In previous years information about council tax bands was collected during the interview survey. This led to a certain amount of missing data for which Band D council tax amounts for the designated local authority area were assigned. Lone persons discount is applied where appropriate.

Output

The Fuel Poverty Full Income variable (fpfullinc) is created by adding the income related to housing costs; i.e. housing benefit, ISMI, MPPI and council tax benefit to the basic income variable (fpbasinc), and by subtracting the council tax payable.

Validation

There are many stages in the process of calculating fuel poverty incomes and at each stage checks are made to ensure as far as possible that the data is reasonable. For example, in the calculation of incomes from private sources, checks are made on data falling outside certain plausibility ranges, as it is possible that coding errors are made during the interview. The characteristics of that case are interrogated and if the amount seems reasonable it is kept. Only when we can be as certain as possible that the data is incorrect do we make an imputation or change. Any changes made are always flagged so that the data can be revisited and the syntax rerun to see what the effect of these imputations might be.

The main external validation techniques applied to the income model are trend analysis over time and comparison with analogous income data from other surveys. The average incomes of the PBU and the household are compared with those of the Family Resource Survey (FRS) and the Expenditure and Food Survey (EFS). The FRS is considered to be the most comprehensive and accurate income survey conducted in this country and one that is dedicated to incomes, something the EHCS is not. It is therefore important to check that the EHCS income model results are comparable.

Fuel Prices

The fuel price element of the fuel poverty model generates a case by case output to be fed into the energy consumption model (see next section).

The price each household pays for its fuel depends on four main factors:

i) The household's location within the country (fuel prices vary regionally)
ii) The choice of supplier
iii) The choice of tariff
iv) The method of payment where relevant (i.e. payment by direct debit, credit etc).

Information on the exact tariff, or the supplier, is not collected in the EHCS. The survey *does* however collect information on the geographical location of each case and on the method of payment (for metered fuels). This allows the application of an average fuel price for each region and method of payment. Fuel prices specific to each household are calculated for each case.

The process involved is shown as a flowchart in appendix C.

Fuel Price Data Sources

Metered Fuels (Electricity and Gas)

The DTI provides average annual prices (January to December) for gas, standard electricity and off-peak (Economy 7) electricity[1]. These prices are split by the electricity supply regions/gas distribution zones and three methods of payment; direct debit, standard credit and pre-payment. The method employed by the DTI is outlined in the flowchart in Appendix D.

An example of this data (the 2002 gas prices) can be found in Appendix E.

Non-Metered Fuels Except Wood (e.g. Coal, LPG, Fuel Oil)

The prices paid for the majority of non-metered fuels (with the exception of wood) are taken from the SALKENT reports. These are independently produced reports which provide the average prices paid for fuels, split into four broad geographical regions. The reports are published twice yearly; once in May and once in October.

For fuel poverty calculations we use the October SALKENT price. Non-metered fuels tend to show considerable seasonality and are more expensive in the autumn and winter. The rationale behind using the October price is that the fuel poor are unlikely to be in a position to buy fuel in advance of need in the summer months. This is also in line with the precautionary principles followed in our analysis.

Wood, Economy 10 Electricity, 24hr Tariff Electricity, Communal Heat From Boilers and Communal Heat From CHP

The prices of wood, Economy 10 electricity, 24hr tariff electricity, communal heat from boilers and communal heat from CHP are not provided by the DTI and not published in the SALKENT reports. For these fuels we use prices adjusted from the

[1] The fuel price data supplied to BRE are also published in the DTI's quarterly energy prices: http://www.dti.gov.uk/energy/statistics/publications/prices/index.html

price published in SAP 2001. It is likely that when SAP 2005 is finalised and published we will take these prices as a new base.

The price of wood is determined by increasing the previously published 2001 SAP price by the same proportion as anthracite nuts have increased since 2001. This follows the SAP methodology used in producing the SAP 1996 and SAP 2001 wood prices.

The "communal from boiler" unit price and the "communal from CHP/waste heat" are determined as a ratio of the gas unit price for that year (the ratios used are from SAP 2001). The communal standing charge is equal to the gas standing charge (again as in SAP 2001). For each year the average England gas price provided by the DTI is taken as the base gas data.

The price of Economy 10 and 24 hr electricity is inflated from the SAP 2001 base prices for these fuels by the same amount as Economy 7 electricity has increased since that year. However, in 2002 and 2003 the price of Economy 7 electricity was in fact lower on average than in 2001. Therefore, following the precautionary principle, we considered it more prudent to continued to use the SAP 2001 published prices for these two fuels.

Methods of payment data

The methods of payment data collected are for gas and electricity only. Each household is asked how they pay for their electricity and gas. For each fuel they have the option of:

a) Direct Debit
b) Standing Order
c) Monthly / Quarterly Bill
d) Pre-payment (key/card or token) meters
e) Included in rent
f) Frequent cash payment method (i.e. more frequent than once a month)
g) Fuel direct / direct from benefits
h) Fixed annual bill (however much gas / electricity is used) e.g. StayWarm (n.b. this question was only added in 2003/04 survey)
i) Other (specified)
j) Not applicable / no mains gas
k) Don't know

There are more methods of payment collected in the EHCS survey than the three methods of payment attached to the prices provided by the DTI (see above and Appendix E). We therefore need to make some assumptions in order to assign each household a method of payment. The current assumptions are as follows:

- Those stating 'direct debit', 'included in rent', 'fuel direct/direct from benefits' or 'fixed annual bill (e.g. StayWarm)' are coded as Direct Debit.
- Those stating 'standing order', 'monthly/quarterly bill' and 'frequent cash payment method (more than once a month)' are coded as Standard Credit.
- Those stating 'pre-payment (key card or token) meters' are coded as Pre-Payment.

For those coded as 'other' and where a description is provided, the most suitable method of payment is assigned for each fuel.

After this process there will still be some cases without a method of payment (i.e. those who have said they don't know, or "other" and where the description is missing or insufficient). For these cases an imputation process is applied in which the method of payment is matched with that of a similar type of household.

Mapping the prices to each household

In addition to matching each household to a fuel based on the method of payment, the household must also be assigned a price based on its location within the country. The EHCS collects information on which government office region (GOR) each household is in however the GORs do not correspond with the electricity supply regions, gas distribution zones or SALKENT regions.

The model matches the fuel prices for each supply/distribution/SALKENT region onto the GORs using a geographical matching technique. This is based upon estimates of the proportion of each government office region within each supply region or distribution zone.

For example, if a household's GOR lies 40% within one supply region and 60% within another supply region the price applied will be a 40/60 weighted average of the two prices. This approach assumes a uniform population density across England.

The prices of wood, Economy 10 electricity, 24hr electricity, communal from boilers and communal from CHP are calculated on a national scale so no regional mapping is necessary.

Energy Consumption

The amount of fuel consumed to provide the energy needs of each household is required as one of the components of the fuel poverty ratio, to assess whether a household is fuel poor.

Under the fuel poverty definition, the energy required to heat and power a home includes energy for:

i) Space heating - E_S (GJ).
ii) Water heating - E_W (GJ).
iii) Lights and appliances - $E_{L\&A}$ (GJ).
iv) Cooking - E_C (GJ).

The BREDEM model [2] is used to predict the energy use of a household where:

$$\text{Total household fuel consumption} = E_S + E_W + E_{L\&A} + E_C.$$

Total household energy-use includes space and water heating (to meet defined standards) and energy for lights, appliances and cooking. The amount of energy required to heat a dwelling will depend on the building specification such as insulation levels, heating systems and the geographical location of the dwelling. A household's demand for energy will depend on the number of people within the household and the habits of these individuals. Information from the EHCS is used to provide details about both dwellings and households. The calculation method for each component of energy consumption is consistent with standard energy models such as the Standard Assessment Procedure (SAP) for calculating energy use in dwellings [2] and the more general model from which SAP is derived (BREDEM) [3].

Comprehensive data about the housing stock and occupants are collected in two main components of the EHCS: the “physical” and “interview” surveys. The physical survey is undertaken by trained surveyors and collects information about all of the physical attributes of the dwelling. The interview survey includes responses obtained from the Household Reference Person (HRP) or their partner about the occupants of the dwelling. This about occupation patterns. The energy use and cost calculation process is summarised in Appendix F.

Dimensions Calculation for Fuel Consumption Calculations

Data from the EHCS physical survey are used to calculate the dimensions of the dwelling and in particular the heated volume and heat loss areas – see Table 2. This involves utilising data from many different modules that relate to different parts of the survey form. The following information is calculated:

- Internal & external wall areas.
- Roof area.
- Room specific floor areas.
- Habitable floor area and footprint area.
- Perimeter of building.
- Ceiling height.
- Window areas.
- Number of floors and rooms in a dwelling.

Key variables are the width and depth of the main and additional parts from the ‘Shape’ section of the survey form. These are used to determine the area (m^2) of each floor. All physical data relating to the dwelling must have a value for the width and depth of the building to be considered part of the main data set. The survey form only has space to include the widths and depths of three levels, so the dimensions of any further levels are imputed. They are assumed to be the same size as the floor below, with the exception of any attics, which are assumed to be half the size of the floor below, and basements, which are assumed to be the same size as the floor above. In general, wherever possible imputations are based on the case in question, not on stereotypes or on the rest of the data set.

Dwelling Fuel Consumption and Energy Use

The calculation of fuel consumption data for fuel poverty requires information from both the physical and interview surveys and the dimensions data to derive the following:

- Heat loss due to conduction from all the external house structure to the external environment.
- Heat gain from solar fluxes and other gains such as from lights and appliances and occupants.
- Heat loss due to ventilation.
- Energy required for space and water heating systems.
- Heating regime of the inhabitants (the details of which will be developed below).
- Energy required for lights, appliances and cooking.

The information collected in the interview and physical surveys is loaded into a series of data files. Table 2 describes the data that are required and how these relate directly to the EHCS forms completed by surveyors and interviewers when they visit a dwelling/household.

	Database	Description of information used in energy calculations
Physical survey	Firstimp	Key dwelling components: • Tenure • Type e.g. mid-terrace • Construction date
	Interior	Rooms in the dwelling – function, dimensions, floor level.
	Introoms	Details of the rooms e.g. presence of solid floors.
	Services	Utilities available e.g. mains gas, off-peak electricity. Primary & secondary heating systems and controls. Water heating system. Type and quantity of roof insulation.
	Flatdets	Dimensions and details specific to flats.
	Numflats	Information about complete building that contains the flat.
	Shape	Complete building dimensions including presence of attics and basements. Construction material of building.
	Elevate	Proportion of external walls that have wall insulation.
	Chimneys	Number of chimneys and construction type.
	Roofstruc	Describes the structure of the roof e.g. flat roof.
	Wallstruc	Detailed construction information for each external wall.
	Dormers	Presence of dormers and bay windows.
	Windows	Number of windows and glazing/frames of windows.
	Doors	Number and type of doors.
	Around	Information about surrounding gardens.
Interview survey	Attitudes	Information about the daily routine of occupants. Information about methods of payment for gas and electricity
	People	Information about the number, sex, age and occupation of inhabitants.
	Workdone	Details of any energy improvements that have been recently installed in the dwelling.

Table 2: Energy consumption input data

Space Heating and Definition of Heating Regime

The amount of energy required for space heating is estimated using the BREDEM 12 algorithm. This model requires the geographical location of a dwelling and the specification of a heating regime (that defines an acceptable level of heating). An acceptable level of heating is defined in terms of the temperature of a dwelling, the extent to which the dwelling space is heated and the number of hours that the occupants spend within the dwelling and require heating.

Geographical Location

BREDEM 12 defines twelve geographical regions for England. These BREDEM regions define average climatic conditions such as temperature, solar flux and wind-speed. Each dwelling in the EHCS has a geographical identifier that can be used to determine in which BREDEM region the property is located.

Demand Temperature

BREDEM 12 suggests that (generally) a house can be split into three distinct zones: a primary heated zone, secondary heated zone and unheated zone, as described in detail in [3]. For the modelling of fuel poverty the demand temperature of all dwellings within the primary zone is assumed to be 21ºC, the secondary zone is assumed to be heated to 18ºC and the temperature of the unheated zone relates to the external temperature and therefore varies depending on the local climatic conditions. These are temperatures that, it has been agreed, should provide an adequate level of thermal comfort and that all households have a right to.

Extent of Heating

Some dwellings are considered excessive in size for the number of occupants that live there. In this case the house is assumed to be "under-occupied" that is, only a proportion of the dwelling will need heating. In order for a dwelling to be considered under-occupied it must fulfil the following criteria that depend on both the number of bedrooms in a dwelling *and* the total floor area of the dwelling:

Bedroom standard

A dwelling is considered to have surplus bedrooms if:

- there are one or more extra bedrooms than *required* for homes without dependent children (children under 18 years)

or

- there are two or more extra bedrooms than *required* for homes with dependent children.

The number of bedrooms required depends on the household constitution. The standard states that:

- A bedroom is required for each couple.
- Children of different sexes below the age of 11 years can share a room.
- Children/adolescents below the age of 21 years of the same sex can share a room.

Floor Area

There is surplus floor area in a property if the floor area of the property is over 200% of that considered to be the "standard" living area required for the number of occupants, as defined by the Parker-Morris Standard [4]. Table 3 defines this standard.

Occupants	Standard living area required (m^2)
1	33.0
2	48.5
3	61.0
4	79.0
5	89.5
6	97.0
7	114.5
8	128.0
9	140.0

Table 3: Parker Morris Standard

For the purposes of fuel poverty, a dwelling is considered to be under-occupied if there are *both* surplus bedrooms and surplus floor area.

If a dwelling is under-occupied then it is assumed that approximately half of the dwelling (based on the total floor-area of the dwelling and the layout of the floors) is heated, that is:

$$A_{heated} \approx 0.5A$$

where A is the total floor area of the dwelling.

Hours of Heating

The length of the heating season must be calculated on a dwelling by dwelling basis as factors such as location and dwelling characteristics can affect the length of time that heating is required throughout the year. This calculation depends on the external temperature for the degree day region for the month and the gain to loss ratio (GLR) of the dwelling and includes consideration of solar gain. The following regimes are applied during the heating season:

A standard heating regime assumes that the occupants are not occupying the dwelling during normal working hours. In this case it is assumed that the occupant heats the dwelling for two hours first thing in the morning and then for seven hours from late afternoon. During the weekend it is assumed that the property is heated throughout the day for 16 hours. The SAP methodology also makes this assumption to calculate the energy consumption in a dwelling.

This heating pattern does not apply for large sectors of the population, in particular the vulnerable such as the elderly and those caring for young children. From 2001, the EHCS interview survey included a direct question to ask whether anybody within the household occupied the dwelling during the morning or afternoon (contained within the database "attitudes.sav"). This question is directly utilised to approximate the heating pattern. If anybody is in the house in *either* the morning or afternoon

during weekdays, the house is assumed to require all day heating. In these cases all day heating is assumed throughout the week.

Heating Regime

The following heating regimes are defined and used to calculate the energy consumption of a household:

	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 21C Secondary living zone 18C

Table 4: The standard heating regime for the fuel poverty heating calculations

	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 21C Secondary living zone 18C

Table 5: The full heating regime for the fuel poverty heating calculations

	Details of PARTIAL heating regime
Heating Pattern	Weekday 16 hours of heating Weekend 16 hours of heating
Heating Extent	Half house
Demand Temperature	Primary living zone 21C Secondary living zone 18C

Table 6: The partial heating regime for the fuel poverty heating calculations

Having defined the heating regime used by each household, the energy use for space heating can be approximated using the BREDEM model which calculates the energy required to bring each dwelling to the designated temperatures and for a set period of time each day and across the year. This calculation needs to take on board details about the heating systems, applied insulation and dwelling construction and materials. Full details of the method are provided in [3].

Water Heating

Energy demand for water heating $Q_U(Watts)$ is given as:

$$Q_U = f_{demand}\,(78 + 52\,N)$$

where N is the number of occupants and f_{demand} is the demand factor. The fuel poverty calculation assumes that all households use 20% more than average i.e. f_{demand} = 1.2. This factor was derived by analysing the change in overall water use since this equation was derived, which implies a 20% increase [5].

Most methods of water heating involve energy losses that relate to storing the water in hot water tanks and distribution losses. Therefore the total water energy demand must satisfy the above equation and account for the energy losses inherently involved in satisfying the supply required. Hot water storage losses are mostly influenced by tank insulation and tank volume. A factor is applied if there is very low occupancy in a property as generally this means that water will be stored for a longer period of time.

The energy required for water heating E_W *(GJ/yr)* is given as:

$$E_W = k(Q_U + Q_{Loss} - Q_S)/\varepsilon_W$$

Where Q_{Loss} *(Watts)* are losses through water storage/distribution, Q_S*(Watts)* is solar-heating, ε_W is the efficiency of the water heater and k is a constant.

Lights and Appliance Energy Use

Energy demand for electrical lights and appliances E_{LA}*(GJ/yr)* is given as:

$$E_{LA} = \begin{cases} 4.47 + 0.0232\,A \times N, & A \times N < 710 \\ 11.98 + (0.0146\,A \times N - 2.78 \times 10^{-6}\,(A \times N)^2), & 2400 > A \times N \geq 710 \\ 31.01, & A \times N \geq 2400 \end{cases}$$

Where: A = Total floor area of the dwelling (m^2).

Cooking Energy Use

Energy demand for cooking is given as E_K*(GJ/yr)*:

$$E_K = f_{Gas}\,(2.98 + 0.6\,N) + f_{Electricity}\,(1.7 + 0.34\,N)$$

Where f_{Gas} and $f_{Electricity}$ are the proportions of demand satisfied from gas or electric cooking, respectively.

Where both gas and electricity are present in a dwelling it is assumed that the proportion of gas and electrical energy demanded for cooking is split equally. Consequently, in this case f_{Gas} =0.5 and $f_{Electricity}$ =0.5.

Where a gas connection is present (i.e. a gas meter is identified by the surveyor), but no gas space or water heating appliances are present, it is assumed that the gas connection is not in use. In these cases 100% of energy demand for cooking is assumed to be met by electricity. No gas standing charge will be applied in the final calculation of fuel cost.

Energy Costs

Total energy consumption is given as:

$$\text{Total energy use } (GJ/yr) = E_S + E_W + E_{L\&A} + E_C$$

Where:
E_S: Energy for space heating;
E_W: Energy for water heating;
$E_{L\&A}$: Energy use for lights and appliances;
E_C: Energy use for cooking.

Different fuels may be used for some or all of these energy contributions and therefore different tariffs, and in some cases standing charges, must be applied to approximate the total cost of energy to the household as described earlier in the fuel price section.

$$\text{Total energy cost } (£) = £_S + £_W + £_{LA} + £_C + £_{Standing}$$

Where:
$£_S$: Energy cost for space and water heating;
$£_{W:}$ Energy cost for water heating;
$£_{LA}$: Energy cost use for lights and appliances;
$£_C$: Energy cost use for cooking;
$£_{Standing}$: Standing charges for all fuels.

Space and Water Heating Systems

Information relating to the heating systems assigned for each dwelling is taken directly from the 'services.sav' file (see table 2). The primary heating group, fuel and type are essential for the allocation of the primary heating system and the calculation of energy use for each household. In cases where primary data are missing for the heating systems, information from 'other heating' (secondary heating) is used in its place. System efficiencies are determined from SAP [6]. Heating system boiler efficiencies can also be assigned from the SEDBUK database [7] in cases where boiler manufacturer and model details have been completed by the surveyor. SAP efficiencies are used in all other cases.

Information relating to the presence and specification of the water heating system is also located in the 'services.sav' file. In the majority of cases the hot water is heated via the space heating system and, where this is the case, the space heating specification will be applied.

Handling Missing Values

Dwelling Data

Where information is required but not available from the form or values are implausible, imputation routines are used and take the form of:-

i) Inferring information from external sources: In many instances it is possible to deduce information by making use of known relationships from other sources. For example, high levels of roof insulation will be installed in newer properties due to building regulations.

ii) Using default data: If information is missing then it can be obtained from what is referred to as 'default' data. These data are constructed using

national averages from the EHCS. Average floor and window areas, together with other building dimensions from the EHCS stock are summarised in an 'average' dataset.

iii) Building age and construction type are also used to impute values where the information is not available from the EHCS form.

Household Data

The number of occupants living in a dwelling and the composition of the household is provided in the interview survey as described in table 2. Data are required for each individual household. If this information is not available then the property is considered to be vacant – the dwelling will not be included for fuel poverty calculations and can be ignored.

Validation

Validation of the fuel poverty energy use and cost outputs is an important process in the delivery of reliable results. The level of validation applied will depend on the level of accuracy quoted, the significance of the indicator, the type of result quoted and the resource provided for the task. Several layers of data validation are applied to the fuel poverty energy use and cost variables. These include cross checking from an independent member of staff, validation through a bespoke model, comparing results against external data sources such as the Energywatch [8] for fuel prices and DUKES [9] for energy use. Additional comparisons are made with the Domestic Energy Factfile [10].

References

[1] Sefton, T and Chesshire, J. Peer Review of the methodology for calculating the number of households in fuel poverty in England. http://www.dti.gov.uk/energy/fuel-poverty/methodology-review/index.html

[2] Anon 2001. The Government's Standard Assessment Procedure for energy rating of dwellings: 2001 edition, BRECSU Report, BRE, Garston, 2001.

[3] Anderson B R, P.F Chapman, N.G Cutland, C. M. Dickson, G. Herderson, J.H. Henderson, P.J. Iles, L. Kosmina and L. D. Shorrock, BREDEM-12 Model Description 2001 update, BRE Report, BRE, Watford, 2001.

[4] Homes for today and tomorrow, Department of the Environment, HMSO 1961.

[5] Estimates of hot water consumption from the 1998 EFUS – Implications for modelling fuel poverty in England, http://www.dti.gov.uk/energy/consumers/fuel_poverty/hot_water_consumption.pdf

[6] Anon 2001. The Government's Standard Assessment Procedure for energy rating of dwellings: 2001 edition, BRECSU Report, BRE, Garston, 2001.

[7] SEDBUK, Boiler Energy Efficiency Database, http://www.sedbuk.com/index.htm.

[8] Energywatch, http://www.energywatch.org.uk.

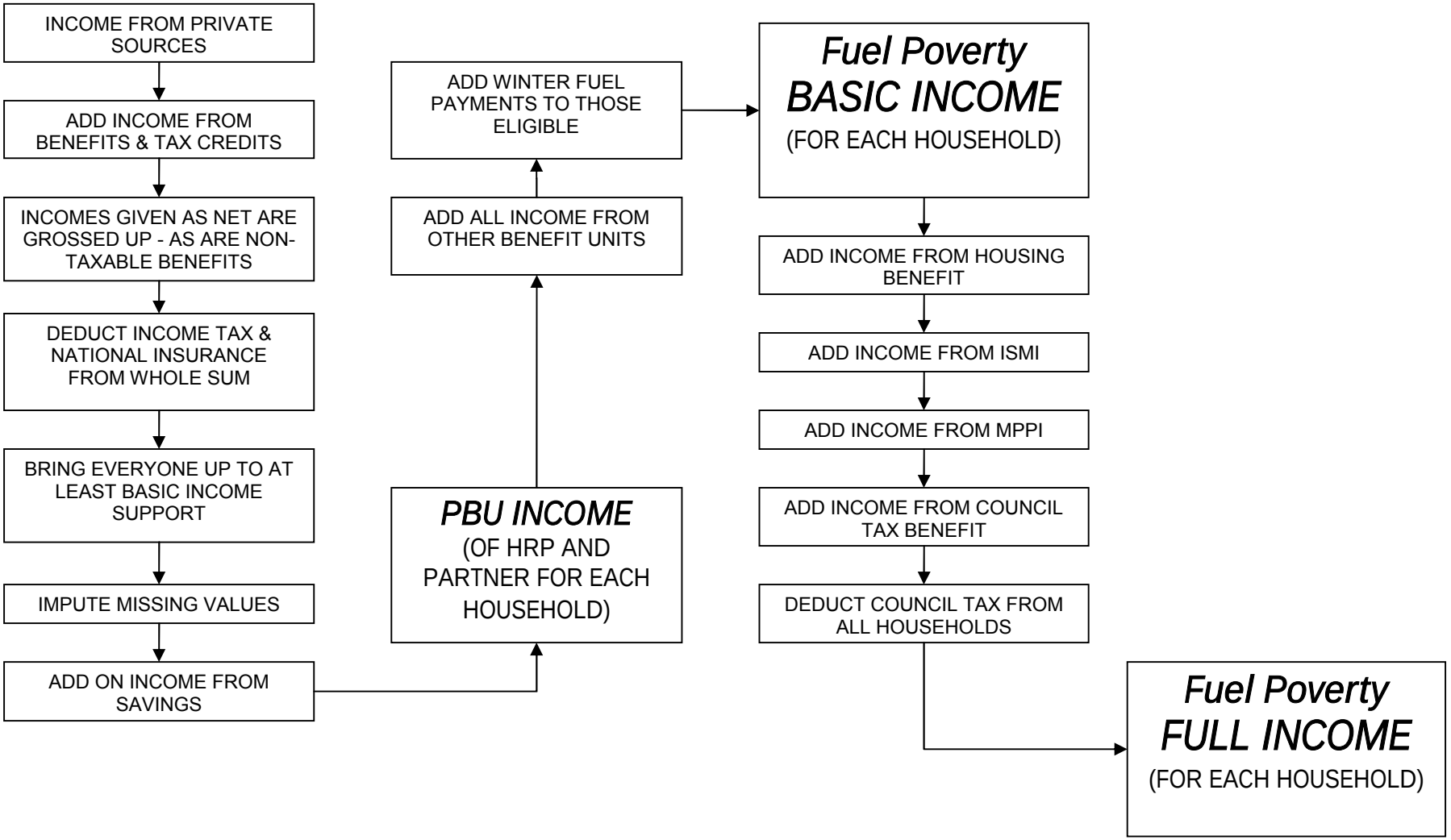
[9] DUKES, Digest of United Kingdom Energy Statistics, http://www.dti.gov.uk/energy/inform/dukes

[10] Utley J, Shorrock L & Brown J. Domestic Energy Fact File: http://projects.bre.co.uk/factfile/index.html

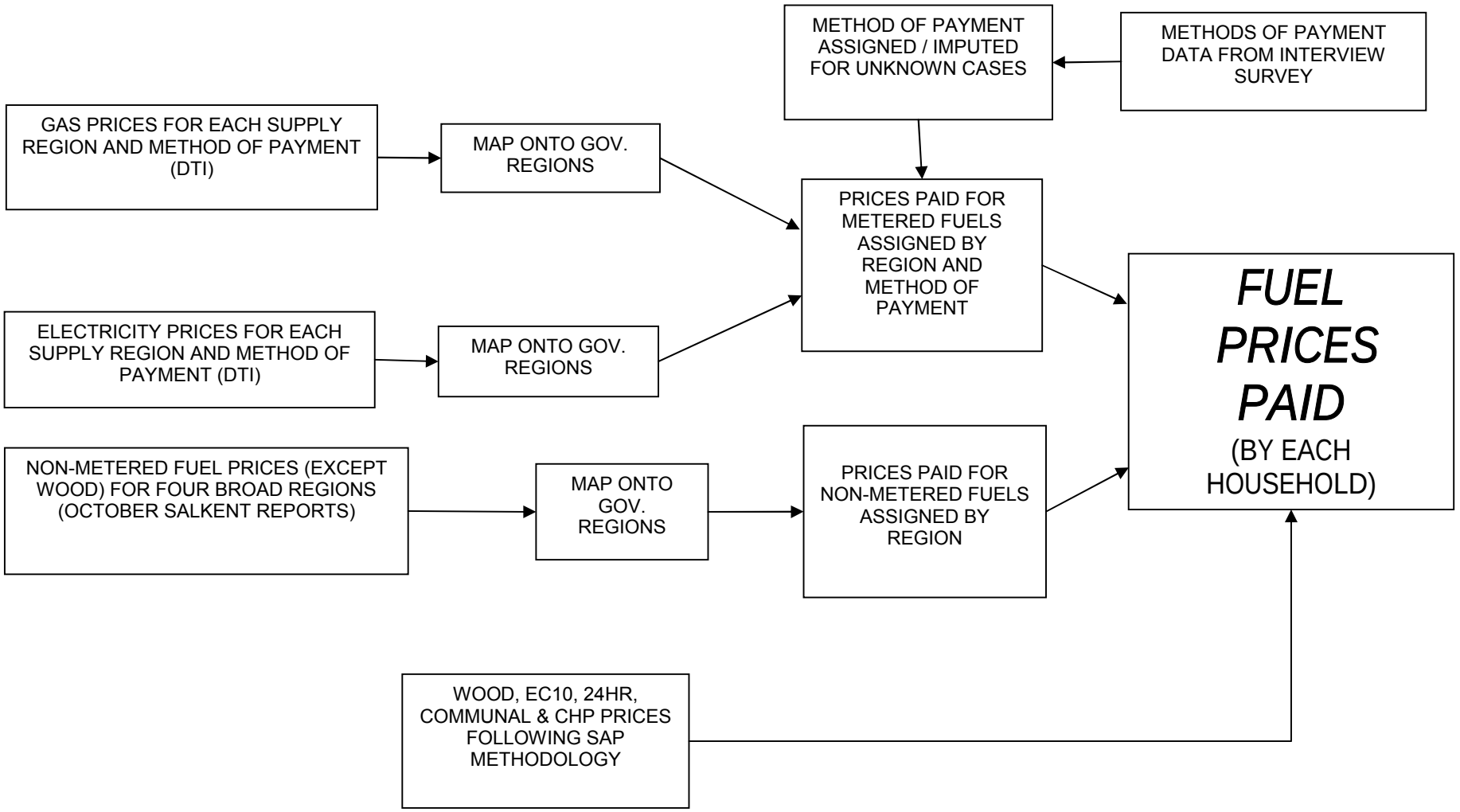
Appendix A

Acronym	Definition
ABU	Additional Benefit Unit
ASHE	Annual Survey of Hours and Earnings
BRE	Building Research Establishment
CHAID	Chi-squared Automatic Interaction Detector
CTB	Council Tax Benefit
CTC	Child Tax Credit
DLA	Disability Living Allowance
DTI	Department of Trade and Industry
DWP	Department of Work and Pensions
EFS	Expenditure and Food Survey
EHCS	English House Condition Survey
FRS	Family Resources Survey
HB	Housing Benefit
HOH	Head of Household
HRP	Household Reference Person
IS	Income Support
ISMI	Income Support for Mortgage Interest
JSA	Jobseekers Allowance
LA	Local Authority
MPPI	Mortgage Payment Protection Insurance
MVS	Market Value Survey
ONS	Office of National Statistics
RSL	Registered Social Letting
SERPS	State Earnings Related Pension Scheme
WFP	Winter Fuel Payment
WTC	Working Tax Credit

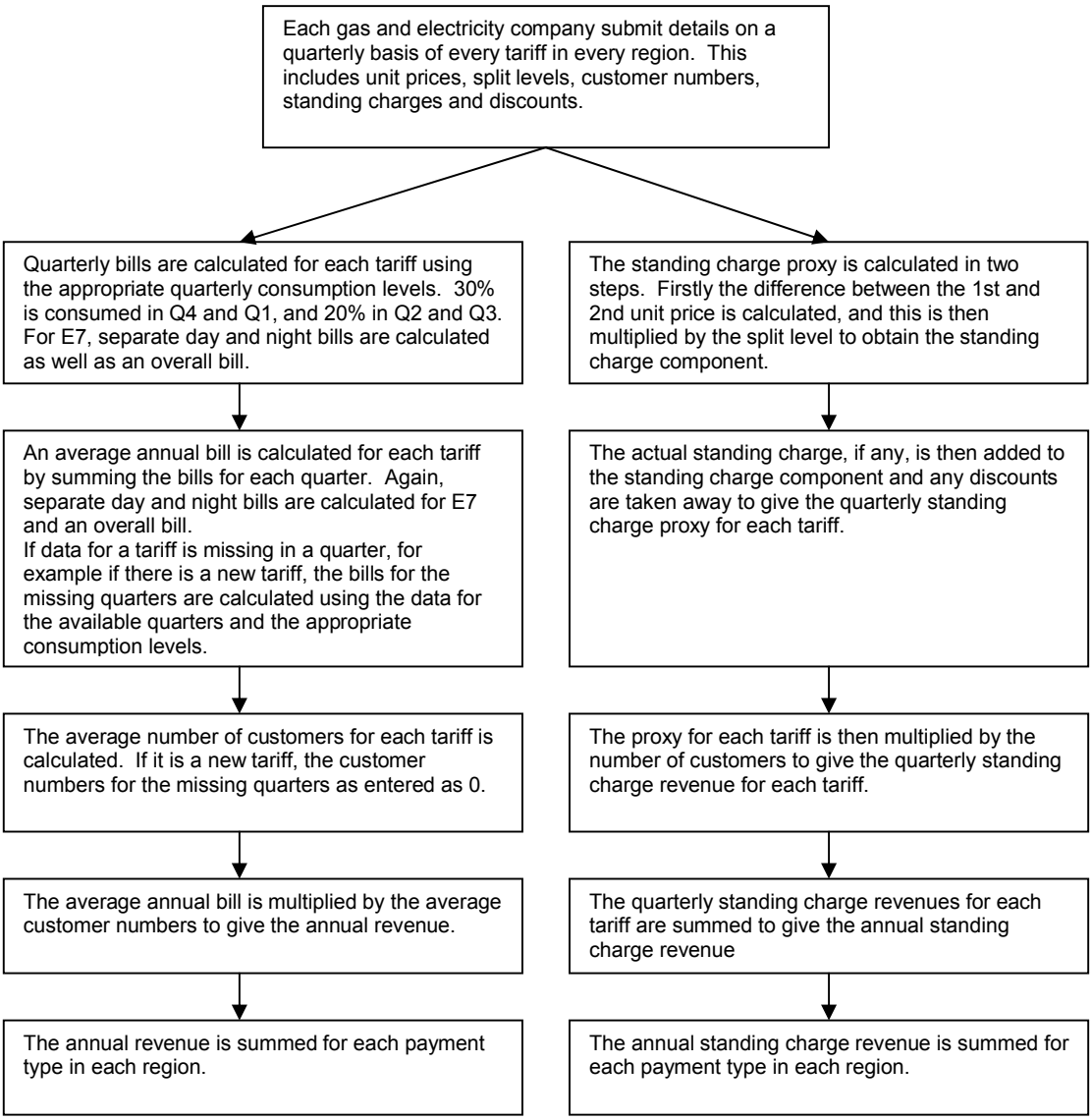
Appendix B


INCOME FROM PRIVATE SOURCES
ADD INCOME FROM BENEFITS & TAX CREDITS
INCOMES GIVEN AS NET ARE GROSSED UP - AS ARE NON-TAXABLE BENEFITS
DEDUCT INCOME TAX & NATIONAL INSURANCE FROM WHOLE SUM
BRING EVERYONE UP TO AT LEAST BASIC INCOME SUPPORT
IMPUTE MISSING VALUES
ADD ON INCOME FROM SAVINGS
PBU INCOME (OF HRP AND PARTNER FOR EACH HOUSEHOLD)
ADD ALL INCOME FROM OTHER BENEFIT UNITS
ADD WINTER FUEL PAYMENTS TO THOSE ELIGIBLE
Fuel Poverty BASIC INCOME (FOR EACH HOUSEHOLD)
ADD INCOME FROM HOUSING BENEFIT
ADD INCOME FROM ISMI
ADD INCOME FROM MPPI
ADD INCOME FROM COUNCIL TAX BENEFIT
DEDUCT COUNCIL TAX FROM ALL HOUSEHOLDS
Fuel Poverty FULL INCOME (FOR EACH HOUSEHOLD)

Appendix C


METHOD OF PAYMENT ASSIGNED / IMPUTED FOR UNKNOWN CASES
METHODS OF PAYMENT DATA FROM INTERVIEW SURVEY
GAS PRICES FOR EACH SUPPLY REGION AND METHOD OF PAYMENT (DTI)
MAP ONTO GOV. REGIONS
PRICES PAID FOR METERED FUELS ASSIGNED BY REGION AND METHOD OF PAYMENT
FUEL PRICES PAID
(BY EACH HOUSEHOLD)
ELECTRICITY PRICES FOR EACH SUPPLY REGION AND METHOD OF PAYMENT (DTI)
MAP ONTO GOV. REGIONS
NON-METERED FUEL PRICES (EXCEPT WOOD) FOR FOUR BROAD REGIONS (OCTOBER SALKENT REPORTS)
MAP ONTO GOV. REGIONS
PRICES PAID FOR NON-METERED FUELS ASSIGNED BY REGION
WOOD, EC10, 24HR, COMMUNAL & CHP PRICES FOLLOWING SAP METHODOLOGY

Appendix D



To calculate the annual standing charge proxy per customer:
annual standing charge revenue / average number of customers

To calculate the average unit cost for gas and standard electricity:
(annual revenue - annual standing charge revenue) / annual consumption

To calculate the average night unit costs:
annual night revenue / annual night consumption

To calculate the average day unit costs:
(total annual revenue - annual standing charge revenue - annual night revenue) / annual day consumption

Appendix E

Averages paid by customers in the year 2002[4][5]

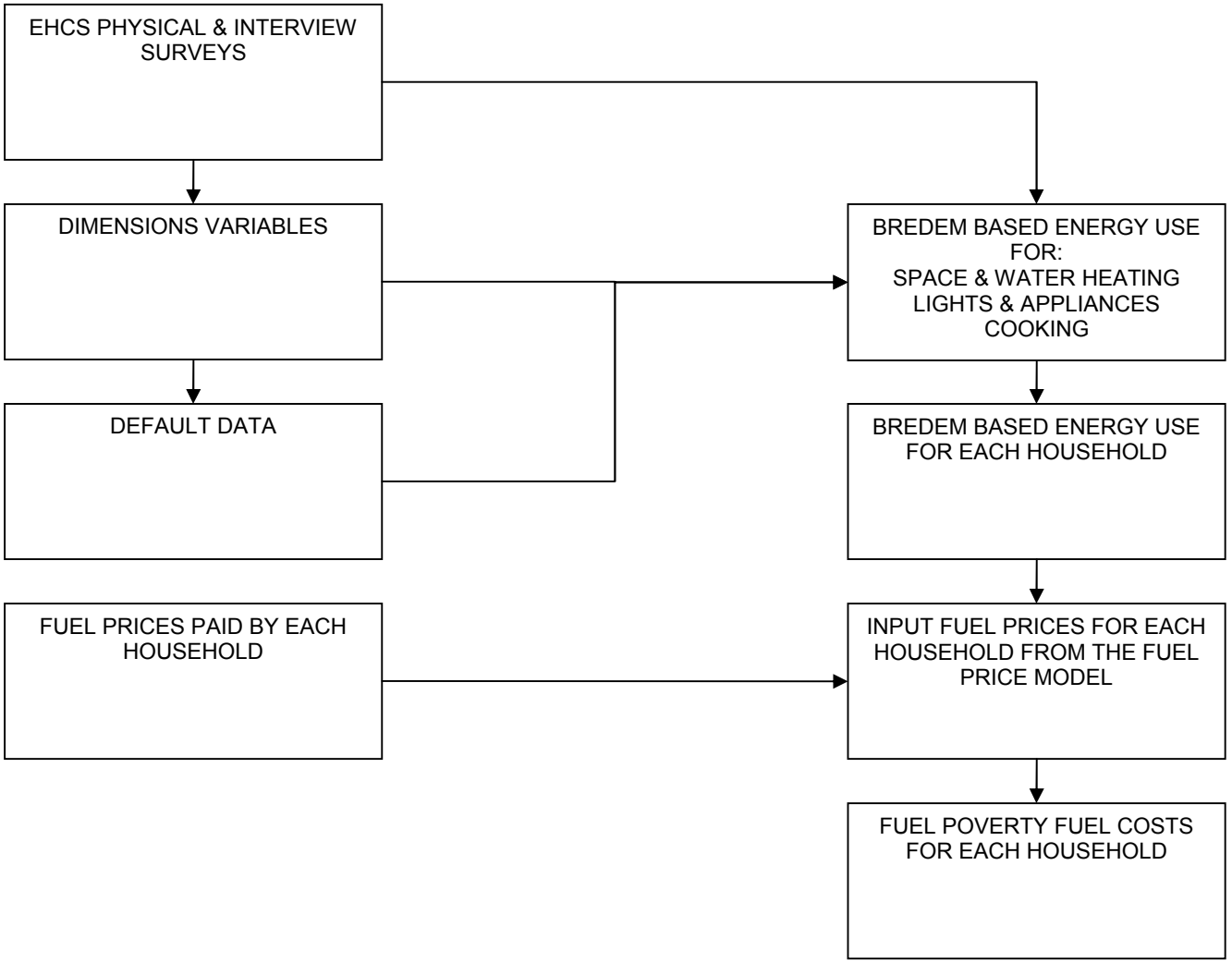
Region[2]	Standing charges proxy (£/year)[1] Credit	direct debit	pre-payment	unit charges (pence/kWh) credit	direct debit	pre-payment
East Midlands	47.34	30.27	51.15	1.45	1.39	1.53
Eastern	46.46	29.51	51.21	1.46	1.39	1.53
North Eastern	46.74	30.05	49.77	1.46	1.40	1.54
North Thames	46.34	30.17	51.79	1.46	1.41	1.53
North Western	45.89	30.00	51.64	1.46	1.40	1.53
Northern	48.08	30.04	51.88	1.47	1.39	1.53
South Eastern	48.21	33.22	51.57	1.46	1.37	1.54
South Western	48.12	31.60	50.86	1.47	1.39	1.53
Southern	47.89	31.90	49.02	1.46	1.38	1.55
West Midlands	48.43	30.13	50.52	1.47	1.41	1.53
England[3]	47.27	30.81	50.95	1.46	1.39	1.53

Source: DTI quarterly domestic fuels inquiry

Notes:
(1) Many companies no longer bill customers for separate standing charges. Instead they charge customers under a two-tier unit price structure with one unit price being charged for the first of a specified number of units each quarter. A second unit price will then be charged for all other units consumed. This proxy for the standing charge is calculated as the difference between the two charges multiplied by the number of units the first is charged at. This method assumes that the threshold for the second unit charge will be reached each quarter.
(2) Regions refer to the Local Distribution Zones used for the gas network and do not necessarily follow the boundaries of any other region.

(3) The sum of the regions listed broadly equates to England, although the Local Distribution Zones do not necessarily follow the Welsh and Scottish borders exactly.
(4) The figures shown related to gas consumed by customers in the period from Q4 2000 to Q3 2001 (and thus billed to customers during 2001) and are weighted by the number of customers on each tariff.
(5) All standing charges and unit prices in this table include VAT at 5 per cent

Appendix F


EHCS PHYSICAL & INTERVIEW SURVEYS
DIMENSIONS VARIABLES
DEFAULT DATA
FUEL PRICES PAID BY EACH HOUSEHOLD
BREDEM BASED ENERGY USE FOR:
SPACE & WATER HEATING
LIGHTS & APPLIANCES
COOKING
BREDEM BASED ENERGY USE FOR EACH HOUSEHOLD
INPUT FUEL PRICES FOR EACH HOUSEHOLD FROM THE FUEL PRICE MODEL
FUEL POVERTY FUEL COSTS FOR EACH HOUSEHOLD