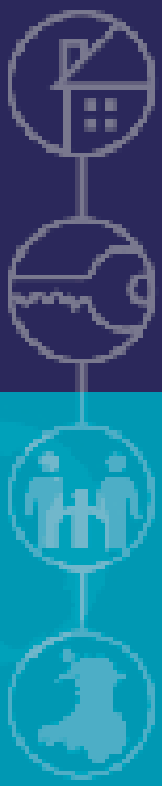
Housing Research Report HRR 3/05 - March 2005

Fuel Poverty in Wales



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PART 1: INTRODUCTION

The Centre for Sustainable Energy was commissioned to carry out this research on behalf of the Welsh Assembly Government. This report completes the first phase of a two phase project.

Background

1.1 Following the requirements of the Warm Homes and Energy Conservation Act 2000, the National Assembly for Wales published its Fuel Poverty Commitment for Wales in March 2003. This commits the Welsh Assembly Government to eradicating fuel poverty (as far as is practically possible) amongst vulnerable households by 2010 and in total by 2018.

1.2 Prior to this study, however, there were no adequate estimates of the number and characteristics of Welsh households experiencing fuel poverty or how these households were distributed geographically. While the National Assembly subscribes to the definitions of fuel poverty used in England, the working definition used for producing estimates for the UK Fuel Poverty Strategy was the eligibility of households for the new Home Energy Efficiency Scheme (HEES) as determined from the 1997/98 WHCS. However, the Fifth report of the Public Accounts Committee of February 2004 found that in England only around a third of the grants made under the Warm Front Scheme, the equivalent to New HEES in Wales, went to the fuel poor and that a third or more of fuel poor households were not eligible for the scheme (Public Accounts Committee, 2004).

1.3 In time, the Welsh Household and Dwelling Survey should provide a clear picture of the extent and nature of fuel poverty, but results will only be available at national level. In the meantime, the Welsh Assembly Government wished to establish firmer national estimates and to understand how the prevalence of fuel poverty varied across the country, as a possible prelude to area-based interventions.

1.4 To this end, this research report provides fuel poverty estimates for Wales on the ‘full’, ‘basic’ and ‘residual’ income definitions. It describes the extent of the problem in the housing stock and amongst the household population and reports on its geographical distribution. The estimates were produced using data obtained from or imputed for the 1997/98 Welsh House Condition Survey (WHCS) and the report also details the methodology involved.

Aims and objectives

1.5 To satisfy the need for better data, the primary aim of the project is to provide equivalent estimates to those used in England of the numbers and characteristics of households in fuel poverty in Wales. Using the existing English definition and new residual income definitions, the detailed objectives of the study are to determine and report on:-

- the extent of fuel poverty in Wales and its causes;
- the distribution of fuel poverty in the Welsh housing stock;

- the distribution amongst the household population; and
- the geographical distribution of fuel poverty in Wales.

1.6 For the last objective, the first stage of the project provides overall estimates for each of four Welsh regions and twenty-two unitary authorities. However, the second main aim of the project is to disaggregate the fuel poverty estimates to the small-area level. To achieve this, a second stage will provide further estimates of fuel poverty for each Electoral Division. This work will be covered in a subsequent report.

1.7 A subsidiary aim of the project is to supply an approach that will be capable of being applied using the results of the Welsh Household and Dwelling Survey. In this first stage report, the project achieves this by describing the modelling used to produce estimates of fuel poverty in Wales. The second stage will similarly detail the methodology used for providing fuel poverty estimates at the small-area level.

Definitions of fuel poverty

1.8 The first two definitions of fuel poverty used in this report are essentially the same as those used for England in the UK Fuel Poverty Strategy. A household is deemed to be in fuel poverty if in order to maintain a satisfactory heating regime and cover other normal fuel costs, it would be required to spend on fuel more than 10% of its net income:-

1. including housing benefit (the 'full' income definition)[1]; and
2. excluding housing benefit (the 'basic' income definition).

1.9 Under each definition, households are considered to be in 'moderate' fuel poverty if their fuel costs exceed 10% but not 20% of their income and in 'severe' fuel poverty if their fuel costs are more than 20% of household income.

1.10 In addition, estimates for fuel poverty are given for residual income (calculated as full net income minus housing costs and equivalised to take account of household size and composition). To compare the distribution of fuel poverty using the residual income definition with that for the full income definition, new thresholds of respectively 13% and 31.5% of income are used as these generate approximately the same number of households in fuel poverty and severe fuel poverty as 10% and 20% of full income. However, the larger numbers generated using the normal thresholds of 10% and 20% of residual income are also given.

1.11 With the definition based on equivalised incomes after housing costs, the distribution of fuel poverty is significantly different to that produced using un-equivalised full and basic incomes, particularly for household variables. The differences arise due to both the deduction of housing costs and the equivalisation of incomes. However, equivalisation is an internationally recognised procedure for measuring income related poverty and is used in the Households Below Average Income (HBAI) series published by the Department for Work and Pensions (DWP).

[1] In England, Income Support for Mortgage Interest is also included but for Wales is ignored in the definitions, the number of such payments being extremely small.

1.12 At the time of writing, a Peer Review established by the Department of Trade and Industry (DTI) and Department for Environment, Food and Rural Affairs (Defra) on the methodology used for calculating the number of households in fuel poverty in England is currently considering whether the HBAI procedure should also be adopted for measuring fuel poverty (Sefton & Chesshire, 2004).

Outline of methodology

1.13 At the time of the project, the latest detailed data on the Welsh housing stock was that provided by 1997/98 WHCS. Consequently, the methodology adopted for this research involved the generation of energy efficiency ratings and fuel poverty estimates from the 1996 English House Condition Survey (EHCS) and the 1997/98 and 1998/99 Family Expenditure Surveys and Family Resources Surveys. These surveys were the most contemporary to the Welsh data.

1.14 It follows from the various definitions of fuel poverty that for each household in the WHCS sample, the project needed to determine:-

1. the fuel costs required to maintain a satisfactory heating regime and cover other normal fuel costs, and
2. the income of the household, on the various income definitions.

This involved the construction of three complex models based on the1997/98 WHCS and other data:- (a) a SAP model, (b) an income model and (c) a fuel poverty model.

a) The SAP model

1.15 To determine the heating costs, the first main stage in the methodology was to provide each individual sample dwelling in the 1997/98 WHCS physical survey with a SAP rating to indicate its energy efficiency. This was done for two main reasons:-

1. the required space and water heating costs could be determined by modifying the fuel costs generated by the SAP (BREDEM-9) model, by replicating the methodology used for the 1996 EHCS fuel poverty estimates, and
2. knowing SAP ratings for the Welsh housing stock could help in understanding the reasons for the extent and distribution of fuel poverty in Wales, energy efficiency being only one of the main determinants of the problem.

1.16 To produce SAP ratings for each sample dwelling, the 100 plus calculations in the Government's standard assessment procedure for the energy rating of dwelling were computed. This involved eleven main stages to determine for each dwelling, the:-

1. overall dwelling dimensions;
2. ventilation rates;
3. heat losses and heat loss parameters;
4. water heating energy requirements;
5. internal gains;

6. solar gains;
7. mean internal temperatures;
8. degree days;
9. space heating requirements;
10. fuel costs; and finally
11. the SAP rating.

1.17 The data for each of these stages was derived mainly from the 1997/98 WHCS physical and interview surveys. However, a number of key variables, such as the floor area of the dwelling, was not collected by the 1997/98 WHCS and these had to be imputed from the 1996 EHCS or other sources. Annex A of the report, describes the SAP model further. It describes each of the eleven main stages, how the data was derived from the 1997/98 WHCS or imputed from the 1996 EHCS or other sources and gives the various SAP calculations involved.

b) The income model

1.18 An eight stage procedure was used to estimate income for the WHCS sample on each of the three income definitions. This was because for over 35% of households in the sample, no information on income was obtained. For those cases where income was provided, it was recorded as falling into one of seven fairly broad bands, rather than as a specific income (which is required for calculating fuel poverty). Data from the WHCS, 1997/98 and 1998/99 Family Expenditure Surveys and Family Resources Surveys was used to impute the income for these households, including those that either 'refused' to answer the income question or answered 'don't know'. The eight stages consisted of:

1. Harmonising the datasets
2. Deflating income
3. Selecting the optimum sub-set of variables to predict income
4. Hot deck imputation of 'missing' gross income bands
5. Imputing gross household income in the WHCS
6. Imputing net household income in the WHCS
7. Re-weighting the WHCS to allow for income non-response
8. Imputing Housing Benefit in the WHCS

1.19 Annex B1 gives a full account of the above procedure. Annex B2 gives details of the 40 socio-demographic and economic variables that were used to harmonise a sub-set of variables that were common to the WHCS, FES and FRS datasets and could be used to predict (impute) missing income band information. Annex B3 gives further details of the Household Below Average Income series and the equivalisation process.

1.20 The imputed household incomes for the WHCS data produced significantly lower average incomes than the FRS and FES data for Wales. To overcome this problem, new weights were calculated to re-gross the WHCS sample so that the imputed incomes more closely reflected the household income distribution in the FES and FRS data. The new weighting was fixed for tenure and household type. Some of the estimates in this report therefore vary slightly from those given in the 1997/98 WHCS main report of March 2001, as a consequence of re-grossing.

c) The fuel poverty model

1.21 The fuel costs for space and water heating generated by the penultimate stage of the SAP model are based on a single standard heating regime, standardised average fuel prices and 'average' climatic conditions for the UK. As in the 1996 English estimates of fuel poverty, these fuel costs needed to be modified to take account of:-

- the use of more than one heating regime to reflect different household needs;
- regional variation in unit fuel prices and standing charges;
- real variation in fuel prices due to the different fuel tariffs of households;
- regional climatic variation affecting required heating costs across the UK; and
- the additional fuel costs associated with cooking, lights and appliances

1.22 As with the SAP model, some of the key data required to make these modifications to the fuel costs were not available from the 1997/98 WHCS and had to be imputed from the 1996 EHCS or other sources. Annex C describes the 1997/98 fuel poverty model and details the methodology for achieving each of the modifications listed above.

1.23 The final stage in the fuel poverty model involved relating the total fuel costs to the three imputed income estimates to produce three fuel poverty variables for each fuel poverty definition. For each definition, a single set of fuel poverty estimates was produced by separately analysing the WHCS data for each of the three fuel poverty variables and then calculating the average of the three results.

Contents of report

1.24 The main body of this report is in six parts. After this introduction, the second part gives the overall frequency of fuel poverty in Wales on each definition and explains why the frequency is at the level it is. It compares the overall frequencies with those of England and looks at comparable levels of fuel poverty in the Government Office regions. The third and fourth parts explore the distribution of fuel poverty in respectively the Welsh housing stock and its household population. Estimates are provided for each fuel poverty definition. These are also compared with the equivalent estimates for England provided by the 1996 EHCS in the case of the 'full' and 'basic' income definitions. The fifth part examines the geographical distribution of fuel poverty in Wales and the final part draws some conclusions.

1.25 The report has three main annexes. Annex A on the SAP model details the methodology for estimating SAP ratings for Wales from the 1997/78 WHCS and other data. Annex B describes the imputing of full, basic and equivalised residual incomes for households from the WHCS and other data. The final annex C on the fuel poverty model describes the methodology for estimating fuel poverty from the 1997/78 WHCS, SAP rating data and imputed incomes.

1.26 A data file is also provided to accompany this report. This gives the SAP rating, imputed household incomes and fuel poverty variables for each fuel poverty definition, for each of the 12,037 households in the combined physical and interview surveys of the 1997/98 WHCS.

1.27 A 'stand alone' summary version of this report is available on the WAG website at www.housing.wales.gov.uk. The WAG can also provide hard copies of the summary, on request.

PART 2: EXTENT OF FUEL POVERTY IN WALES

Headline figures

2.1 In 1997/98, Wales had a high level of fuel poverty, with around 360,000 or 31% of all households needing to spend over 10% of their 'full' net income to maintain satisfactory heating and cover other normal fuel costs. These include some 71,000 households or 6% who were in severe fuel poverty. This frequency compares with the 1996 headline figure for England of 22%, of which only 3% were in severe fuel poverty (DETR, 2000 & DTI/DEFRA, 2001)[2]. While Wales has a greater proportion of severe fuel poor households than England, the Welsh estimates of overall fuel poverty are comparable with the highest frequencies in the 1996 English Government regions. The incidence of fuel poverty in Merseyside and the North East was also over 30%, while Yorkshire and Humberside had nearly 30% of households in fuel poverty.

2.2 Wales fares somewhat better against England and the highest English regions when fuel poverty is measured using 'basic' net income excluding housing benefits. Wales has fewer households in receipt of housing benefit (13%) than England (17%) and the northern regions of England where between 20% and 26% of households were on housing benefit in 1996 (see last row of middle section of Table 2.1). This reflects the lower proportion of tenanted properties in Wales. Around 28% of households rented from a local authority, private or registered social landlord in Wales compared with, for example, 38% in the North East region of England.

Table 2.1: Severity of fuel poverty in Wales, England and three highest English regions

Thousand households/ *Column percentages*

Severity of fuel poverty using definition based on :-	Frequencies for Wales in 1997/98		England in 1996	Mersey-side[1]	North East	Yorks & Humber
	thousands	*percent*	*percent*	*percent*	*percent*	*percent*
FULL INCOME						
Households not in fuel poverty	797	*68.9*	*78.2*	*69.2*	*69.4*	*70.3*
In moderate fuel poverty	289	*25.0*	*18.5*	*26.4*	*26.3*	*26.1*
In severe fuel poverty	71	*6.2*	*3.3*	*4.3*	*4.3*	*3.7*
Total fuel poor households	**360**	***31.0***	***21.8***	***30.8***	***30.6***	***29.7***
BASIC INCOME						
Households not in fuel poverty	763	*66.0*	*73.3*	*63.4*	*64.8*	*66.3*
In moderate fuel poverty	276	*23.9*	*21.3*	*29.2*	*27.9*	*26.9*
In severe fuel poverty	118	*10.2*	*5.4*	*7.4*	*7.4*	*6.9*
Total fuel poor households	**394**	***34.0***	***26.7***	***36.6***	***35.2***	***33.7***
All households receiving HB		*13.3*	*17.2*	*23.4*	*26.3*	*20.4*
RESIDUAL INCOME	Equivalised		Not equivalised			
Households not in fuel poverty	647	*55.9*	*64.7*	*56.5*	*55.4*	*60.6*
In moderate fuel poverty	328	*28.3*	*23.8*	*28.1*	*29.3*	*25.3*
In severe fuel poverty	182	*15.8*	*11.5*	*15.4*	*15.3*	*14.1*
Total fuel poor households	**510**	***44.1***	***35.3***	***43.5***	***44.6***	***39.4***
Total households (thousands)	**1,157**	***100.0***	**19,643**	**559**	**1,069**	**1,954**

1 Merseyside later amalgamated with North East GO region

[2] For a stricter comparison between Wales and England, the English fuel poverty estimates are calculated using actual cooker types and thus may be marginally different from those published in the 1996 EHCS Energy Report and UK Fuel Poverty Strategy.

2.3 Using 'basic' instead of 'full' income in the definition, therefore, lowers the extent to which the proportion of fuel poor households in Wales exceeds the English total. Under the basic income definition, the incidence of fuel poverty in Wales exceeds that in England by 27%, compared to 43% using the full income definition. On the basic income definition, Merseyside and the North East have higher levels of fuel poverty than Wales and the rate in Yorkshire and Humberside is only marginally lower. *(Table 2.1)*

2.4 Using equivalised residual incomes, after housing costs, and keeping the 10% and 20% thresholds, would substantially increase the total number of households classed as fuel poor and in severe fuel poverty. Around 510,000 or 44% of all households would need to spend more than 10% of their residual incomes on fuel; 182,000 or 16% would need to spend over 20%.

2.5 Estimates using equivalised incomes are not available for England. However, residual incomes after the simple deduction of annual rents or mortgage payments, show 35% of households in England would have needed to spend more than 10% of their residual income on fuel in 1996, including 11% who would have required to spend more than 20%. The comparable figures for Merseyside were 44% and 15% and, for the North East region, 45% and 15% respectively. These are very similar to the Welsh figures for fuel poverty and severe fuel poverty (44% and 16%), based on equivalised residual incomes.

2.6 As 10% and 20% of residual income produce substantially higher fuel poverty figures, these traditional thresholds are not particularly suitable for the purposes of directly comparing distributions with those produced using the full income 'target' definition. To determine the distributional effects of using the residual income definition of fuel poverty, new thresholds for fuel poverty and severe fuel poverty of respectively 13% and 31.5% of residual income were chosen. These new threshold were selected to produce a similar number of fuel poor households as those given under the 10% and 20% of **full income definitions**. With the new thresholds, around 362,000 or 31% live in fuel poverty in Wales, of which 73,000 or 6% are in 'severe' fuel poverty[3]. Under the residual income definition, the number of households classed as fuel poor and in severe fuel poverty, using the new and traditional thresholds are shown in Table 2.2 below.

[3] Rather than having an odd threshold, such as 13.043%, that would give exactly the same number (360,000) as 10% of full income, it was judged more practical to round the threshold to 13% as this gave a very similar total and produced virtually the same distribution. Similarly, 31.5% of residual income was chosen as this was the threshold (to the nearest 0.5%) that gave the 'same' number of households in severe fuel poverty as 20% of full income (72,000).

Table 2.2: Severity of fuel poverty in Wales using equivalised incomes after housing costs

Thousand households/ *Row percentages*

		Wales 1997/98			Wales 1997/98	
		thousands	*percent*		thousands	*percent*
RESIDUAL INCOME						
Not in fuel poverty	Using	795	*68.7*	Using	647	*55.9*
Moderate fuel poverty	new 13%	290	*25.0*	Normal 10%	328	*28.3*
Severe fuel poverty	and 31.5%	73	*6.3*	and 20%	182	*15.8*
	thresholds			Thresholds		
Total fuel poor		**362**	***31.3***		**510**	***44.0***
Total households		**1157**	***100.0***		**1157**	***100.0***

Reasons for the high incidence in Wales

2.7 The high incidence of fuel poverty in Wales compared to England can be attributed to a combination of factors:-

- Wales had generally low levels of full income in 1997/98. Only three of the then English Government regions (the North East, Merseyside and Yorkshire and Humberside) recorded lower averages in the 1996 EHCS, despite the EHCS's earlier survey date.
- Due largely to its older stock, Wales is estimated to have had a generally lower standard of energy efficiency than England and a higher proportion of particular inefficient dwellings than any of the English regions.
- With its largely rural hinterland, Wales also had a higher proportion of homes lacking a gas supply and reliant on more expensive fuels, resulting in lower SAP ratings.
- Compared to areas in England, Wales also appears to have had higher unit fuel costs and standing charges, particularly for electricity, despite the period between the two surveys and the generally falling fuel prices at that time.

- Wales also had more homes which were under-occupied and where, consequently, the total household income was more liable to be out of balance with the total fuel costs.
- With significantly fewer flats than England, Wales had a comparative dearth of small dwellings which, given the same standard of energy efficiency, would have cost less to heat.

Comparison with English regions

2.8 The above factors are illustrated in Tables 2.3 and 2.4. Table 2.3 shows the level of fuel poverty in England, Wales and the English Government regions and Table 2.4 shows the main causal factors of fuel poverty. In Table 2.3, the first three columns of figures give respectively the total number and percentage of households that are in fuel poverty (of whatever severity) and the percentage that are in severe fuel poverty on the 'full' income definition, while the next three columns provide the equivalent estimates using 'basic' income. The final two columns show the proportion of households in each area in receipt of housing benefit and the total number of households in the country or region.

Table 2.3: Levels of fuel poverty in Wales and England and the English Regions on the full and basic income definitions

Thousand households/ *Row percentages*

Countries and government office regions in 1996	Full income definition			Basic income definition			All	Total
	All household in fuel poverty		In severe FP	All household in fuel poverty		In severe FP	All Hholds with HB	house holds[1]
	thousands	*percent*	*percent*	thousands	*percent*	*Percent*	*percent*	thous.
Wales in 1997/98	**360**	***30.0***	***6.2***	**394**	***34.0***	***10.2***	***13.3***	**1,157**
Merseyside[1]	184	*30.8*	*4.3*	219	*36.6*	*7.4*	*23.4*	559
North East	327	*30.6*	*4.3*	377	*35.2*	*7.4*	*26.3*	1,069
Yorks. & Humber	581	*29.7*	*3.7*	660	*33.7*	*6.9*	*20.4*	1,954
North West	503	*22.2*	*2.6*	660	*29.1*	*4.4*	*18.4*	2,266
West Midlands	551	*26.8*	*4.4*	641	*31.1*	*7.1*	*19.0*	2,060
East Midlands	382	*23.3*	*4.6*	446	*27.2*	*6.3*	*14.3*	1,642
South West	460	*23.2*	*4.1*	526	*26.6*	*5.3*	*11.1*	1,978
London	475	*16.9*	*1.9*	687	*24.4*	*5.0*	*23.3*	2,816
Eastern	355	*16.5*	*2.9*	454	*21.1*	*4.1*	*13.6*	2,158
South East	453	*14.6*	*2.4*	572	*18.4*	*3.6*	*11.0*	3,101
England in 1996	**4,274**	***21.8***	***3.3***	5,241	*26.7*	*5.4*	***17.2***	**19,643**

1 Merseyside later amalgamated with North East GO region

2.9 In Table 2.4 below, the first four columns of figures show for each country and region, the average of the full, basic and residual net household incomes as used in the 1997/98 Welsh and 1996 English estimates of fuel poverty and the proportion of households that have full incomes lower than £9,100. This represented the lowest third of all annual incomes in England. This is followed by two columns showing the average SAP rating in each area and the percentage of homes that are particularly inefficient, having a SAP rating of 20 or under.

2.10 The next column shows the average unit cost of standard tariff electricity (in pence per kilowatt hours) for four regional groupings, as provided by SALKENT for October 1997 and the equivalent Sutherland Tables for May 1996. These groups approximate to the Government regions as indicated by the four different prices given. The next column shows the proportion of households that are 'under-occupying' their home, having a floor area per person that is over 50% higher than the old Parker Morris space standard [4]. The penultimate column covers a related factor that will tend to reduce the incidence of fuel poverty, namely the percentage of small homes (having a floor area of under 69m^2). *(Table 2.4)*

Table 2.4: Causal Factors in Fuel Poverty in Wales and England and the English Regions

Pounds/ *Row percentages* /SAP ratings/ p-kWh/ households

Governt Offices in 1996	**a. Full income** Less than Mean £	£9100 *percent*	**b. Basic inc.** Mean £	**c. Residual[1]** Mean £	**d. Energy SAP ratings[2]** Mean SAP	< 20 *percent*	**e. Electric prices[3]** p/kWh	**f. Under-occupy** > 1.5PM *percent*	**g. Small homes** < 69 m^2 *percent*	**Total households[1]** thous.
Wales 1997/98	**14,539**	***37.3***	**14,242**	**10,957**	**40.5**	***14.5***	**7.49**	***58.9***	***21.1***	**1,157**
Merseyside [4]	14,187	*38.4*	13,799	11,391	40.4	*10.8*	6.97	*53.3*	*26.9*	559
North East	13,921	*41.5*	13,577	11,306	43.0	*8.5*	6.97	*55.1*	*28.8*	1,069
Yorks. & Humber	14,331	*38.1*	14,024	11,901	42.3	*8.5*	6.97	*57.3*	*32.1*	1,954
North West	15,715	*37.4*	15,363	12,232	44.8	*6.6*	6.97	*60.3*	*26.5*	2,266
West Midlands	14,907	*35.5*	14,602	12,306	40.7	*10.7*	7.33	*54.7*	*30.5*	2,060
East Midlands	16,213	*33.1*	15,984	13,408	41.0	*8.6*	7.33	*58.7*	*26.3*	1,642
South West	15,953	*32.5*	15,740	13,040	44.6	*8.4*	7.64	*64.5*	*27.1*	1,978
London	17,466	*34.0*	16,943	13,253	45.3	*8.8*	7.35	*46.4*	*43.4*	2,816
Eastern	17,511	*28.0*	17,259	13,553	45.1	*5.5*	7.35	*57.7*	*31.1*	2,158
South East	18,172	*26.2*	17,944	14,864	45.7	*8.2*	7.35	*57.7*	*29.6*	3,101
England 1996	**16,250**	***33.4***	**15,937**	**13,018**	**43.8**	***8.2***	**7.22**	***56.6***	***31.0***	**19,643**

[4] This is a more general measure of under-occupation than used in the definition of fuel poverty, where only households that are living at more than double the Parker Morris Standard and have spare bedrooms are assumed to require only partial heating.

1. Residual incomes are equivalised for Wales but not for England or the English regions
2. 1997/98 WHCS based and 1996 EHCS estimates
3. SALKENT for Wales (October 97) & Sutherland Tables for England (May 96)
4. Later amalgamated with the North West region.

a) Full Incomes

2.11 The average imputed full net income for households in Wales in 1997/98 of £14,539 is compatible with the average EHCS full income estimates, including the same sources of income and benefits. However, it is based on mid 1997/98 prices, unlike the English estimates which are at 1996 EHCS prices. The equivalent 1996 price for the Welsh average was £13,772 per annum. However, despite inflation, it remains broadly comparable with the lower average levels of incomes found in Merseyside, the North East region and Yorkshire and Humberside in 1996.

b) Basic Incomes

2.12 The average imputed 'basic' net income for households in Wales in 1997/98 of £14,242 is also comparable with the average EHCS basic income estimates. The English estimates exclude Income Support for Mortgage Interest (ISMI), whereas the Welsh estimates do not. However, the number of such payments in Wales was extremely small. The equivalent 1996 price for the Welsh average is £13,491 per annum, again putting it below the average for Merseyside, the North East and Yorkshire and Humberside at that time.

c) Residual Incomes

2.13 The residual incomes for Wales are calculated as in the DWP's Households Below Average Income (HBAI) series and are equivalised to reflect the extent to which households of different size and composition require a different level of income to achieve the same standard of living. The incomes for England and the English GO regions are not equivalised, but are also calculated after the deduction of housing costs (annual rents and mortgage payments). Despite these methodological differences, the Welsh average again appears compatible with the averages for Merseyside, the North East and Yorkshire and Humberside.

d) Energy SAP ratings

2.14 The estimated average energy rating for Wales is very similar to that recorded in Merseyside and the West Midlands in 1996. However, in 1997/98, Wales still had a higher proportion of homes with SAP ratings under 20 (15%) than either of these regions, both of which had 11% below SAP 20 in 1996. By comparison, the North East and Yorkshire and Humberside had relative high mean SAP ratings (43 and 42 respectively) and fewer homes rated below 20 (9%).

e) Electricity (and gas) prices

2.15 By 1997/98 the average unit price of standard tariff electricity had fallen in Wales and the South West from 7.64 p/kWh in May 1996 to 7.49 p/kWh in October 1997. However, it still remained higher than the 1996 average for all the remaining fuel areas, particularly Northern England, where the Welsh average was still 8% higher in cash terms. Moreover, standing charges for electricity also remained significantly higher in Wales. For example, SWALEC customers paying quarterly were charged a total of £43.98 for 1997/98, compared with annual 1996 standing charges of £31.72 for MEB and £25.00 for SEEBOARD quarterly customers.

2.16 The higher electricity prices were somewhat offset by falling gas prices, but the average unit British Gas price for Wales and the South West fell by under 5% between May 1996 and October 1997 from 2.05 to 1.95 p/kWh. Moreover, over the same period, the British Gas standing charge increased by nearly 8% in cash terms from £35.55 to £38.33, even after including the reduction in VAT on fuel from 8% to 5% in September 1997.

f) Under-occupancy

2.17 A direct indication of the degree to which dwelling sizes are appropriate to the size of households in an area is given by the extent to which households are exceeding the 1968 Parker Morris space standard. This set minimum floor areas for different household sizes with, for example, 48.5 m^2 being the minimum for two persons and 61.0 m^2 for three person households. The next column of Table 2.4 shows the proportion of households whose homes exceed the Parker Morris standard by more than 50%. As can be seen, the 59% figure for Wales is higher than that for England and most English regions. This is particular the case for Merseyside and the North East where the comparative figures for 'under-occupancy' in 1996 were 53% and 55% respectively.

g) Small homes

2.18 Dwelling sizes have a substantial influence on fuel costs and therefore on levels of fuel poverty. As households on the lowest incomes tend to be small and often elderly, the proportion of appropriate small homes can be important to reducing levels of fuel poverty. In 1997/98, Wales had only a slightly lower proportion of one and two person households (58%) than England (62%), but with fewer flats had a substantially smaller proportion of small homes. Only 21% of the Welsh stock had floor areas of under 69 square metres, compared with 31% of homes in England. With a similar percentage of small households (59% & 60% respectively), Merseyside and the North East also had significantly more small homes than Wales. Around 27% and 29% of dwellings in the 2 regions had floor areas of under 69 square metres. *(Table 2.4)*

PART 3: FUEL POVERTY IN THE HOUSING STOCK

Fuel poverty by tenure

3.1 The distribution of fuel poverty across the four main tenures in Wales also exhibits a significantly different pattern to that in England. In both countries, however, the owner occupied stock has the lowest proportion but greatest number of fuel poor - due to the predominant size of the sector - while the housing association sector has the lowest number of fuel poor, primarily due to its relatively small size.

3.2 The main difference between the two countries lies in the fact that the local authority housing takes the 'top' position in Wales (with 51% of tenants being fuel poor on the full income definition) while this position is held by the privately rented sector in England (with 39% fuel poor). In Wales, both the housing association and the privately rented sector, have 44% of households in fuel poverty, while the owner occupied stock has significantly less (24%). In both countries, the private rented sector has the highest proportion of severe fuel poverty. However, 10% of local authority tenants in Wales also live in severe fuel poverty – only slightly lower than the figure for private rented tenants (12%).

3.3 Under the basic income definition, local authority housing remains the most deprived, but now tenants of registered social landlords run a very close second with 61% in fuel poverty. The gap between the owner occupied and rented sectors increases substantially. Over 20% of households now fall into severe fuel poverty in each of the three rented sectors, compared to only 4% of owner occupiers. This is because only tenants are eligible for housing benefit. Therefore, the change from the 'full' to the 'basic' income definition only reduces incomes and raises fuel poverty in homes rented from a local authority, registered social landlord or private landlord, while levels in the owner occupied sector remain the same. *(Table 3.1)*

Table 3.1: Fuel poverty in Wales and England by tenure (full & basic incomes)

Thousand households/ *Row percentages*

Tenure by country	Full income definition			Basic income definition			Total
	All households In fuel poverty		In severe FP	All households in fuel poverty		In severe FP	house-holds
	Thousands	*percent*	*Percent*	Thousands	*percent*	*Percent*	thousands
WALES							
Local authority/DBRW[1]	105	*51.1*	*10.4*	127	*61.9*	*25.2*	205
Housing associatn/RSL	18	*44.5*	*7.6*	25	*61.1*	*22.2*	41
Private rented	36	*44.4*	*12.5*	40	*49.8*	*24.6*	81
Owner occupied	201	*24.3*	*4.4*	201	*24.3*	*4.4*	830
Totals for Wales	**360**	***31.0***	***6.2***	**394**	***34.0***	***10.2***	**1157**
ENGLAND							
Local authority	1183	*35.4*	*4.0*	1765	*52.9*	*10.5*	3340
Housing associatn/RSL	233	*25.7*	*2.7*	430	*47.5*	*7.4*	905
Private rented	702	*38.6*	*10.2*	861	*47.4*	*17.6*	1817
Owner occupied	2185	*16.1*	*2.2*	2247	*16.5*	*2.4*	13581
Total for England	**4274**	***21.8***	***3.3***	**5241**	***26.7***	***5.4***	**19643**

1 Development Board for Rural Wales

3.4 When equivalised residual incomes and the 13% threshold for defining fuel poverty is used, the distribution of fuel poverty by tenure changes more fundamentally. The proportion of households in the private rented sector classed as fuel poor increases from 44% to 55%, thereby pushing local authority housing into second position, albeit with 53% of households in fuel poverty. Maintaining the 10% threshold with residual incomes keeps local authority homes in the 'top' position, with the private sector now second. However, the proportion of households classed as fuel poor increases substantially. Two out of three local authority tenants live in fuel poverty and 2 out of 5 private tenants are in severe fuel poverty. *(Table 3.2)*

Table 3.2: Fuel poverty in Wales by tenure (equivalised residual incomes)

Thousand households/Row percentages

Tenure	Residual – new thresholds			Residual - normal thresholds			Total
	All households in fuel poverty		In severe FP	All households in fuel poverty		In severe FP	house-holds
	thousands	*percent*	*percent*	thousands	*percent*	*percent*	thousands
Local authority/DBRW[1]	109	*52.9*	*11.5*	136	*66.2*	*29.9*	205
Housing association/RSL	20	*48.3*	*9.5*	25	*62.4*	*25.9*	41
Private rented	44	*54.7*	*25.0*	53	*64.9*	*39.2*	81
Owner occupied	190	*22.8*	*3.0*	296	*35.6*	*9.5*	830
Totals	**362**	***31.3***	***6.3***	**510**	***44.1***	***15.8***	**1157**

1 Development Board for Rural Wales

Date of construction

3.5 Unlike England, where the highest proportion of fuel poverty is found in the oldest housing, the highest frequency in Wales (39%) is in housing built between 1945 and 1965. Most of this occurs in the local authority stock of this age. However, pre 1919 housing is second with 35% and, as in England, this stock has both the largest numbers of fuel poor and the highest levels of severe fuel poverty. In both countries, post 1964 housing has the lowest levels of fuel poverty and severe fuel poverty. Using basic incomes in the calculation, the distribution of fuel poverty by age of construction follows a similar pattern, except that the post-war stock also now has the highest proportion of households (13%) in severe fuel poverty .*(Table 3.3)*

Table 3.3: Fuel poverty in Wales and England by date of construction (full & basic incomes)

Thousand households/ *Row percentages*

Date of construction by country	Full income definition: All households In fuel poverty Thousands	Full income definition: All households In fuel poverty *percent*	Full income definition: In severe FP *percent*	Basic income definition: All households in fuel poverty thousands	Basic income definition: All households in fuel poverty *percent*	Basic income definition: In severe FP *percent*	Total households thousands
WALES							
Pre 1919	127	*35.2*	*8.3*	132	*36.4*	*10.5*	361
1919 to 1944	53	*32.8*	*5.9*	56	*34.9*	*10.6*	161
1945 to 1964	90	*38.5*	*6.8*	99	*42.3*	*12.8*	234
Post 1964	90	*22.5*	*4.0*	107	*26.7*	*8.1*	401
Totals for Wales	**360**	***31.0***	***6.2***	**394**	***34.0***	***10.2***	**1157**
ENGLAND							
Pre 1919	1272	*27.8*	*6.0*	1443	*31.5*	*8.4*	4583
1919 to 1944	915	*24.4*	*3.5*	1071	*28.6*	*5.7*	3742
1945 to 1964	969	*23.6*	*2.8*	1278	*31.1*	*5.6*	4113
Post 1964	1110	*15.4*	*1.6*	1440	*20.0*	*3.0*	7205
Totals for England	**4274**	***21.8***	***3.3***	**5241**	***26.7***	***5.4***	**19643**

3.6 Unlike tenure, the residual income definition has little effect on the distribution of fuel poverty by date of construction. Using the thresholds of 13% and 31.5%, the proportions of households in each age of housing in both fuel poverty and severe fuel poverty are very similar to those for 10% of full income. Using 10% and 20% of residual income increases the numbers of fuel poor, but the rank order remains unchanged, except that the post-war stock now has the highest percentage of households in severe fuel poverty - as under the basic income definition. *(Table 3.4)*

Table 3.4: Fuel poverty in Wales by date of construction (Equivalised residual incomes)

Thousand households/Row percentages

Date of construction	Residual – new thresholds: All households in fuel poverty Thousands	Residual – new thresholds: All households in fuel poverty *percent*	Residual – new thresholds: In severe FP *percent*	Residual - normal thresholds: All households in fuel poverty thousands	Residual - normal thresholds: All households in fuel poverty *percent*	Residual - normal thresholds: In severe FP *percent*	Total households thousands
Pre 1919	127	*35.1*	*8.3*	176	*48.6*	*18.0*	361
1919 to 1944	54	*33.5*	*6.5*	78	*48.4*	*16.7*	161
1945 to 1964	90	*38.3*	*6.9*	122	*52.1*	*19.5*	234
Post 1964	92	*22.9*	*4.0*	135	*33.6*	*11.2*	401
Totals	**362**	***31.3***	***6.3***	**510**	***44.1***	***15.8***	**1157**

Type of dwelling

3.7 End terraced housing has the highest rates of fuel poverty and severe fuel poverty in both Wales and England, although the incidence is higher in Wales (38% and 9% respectively). Such housing often has a larger floor area and a lower energy rating due to its age and higher external wall areas. Similarly, mid-terraced and semi-detached properties reflect the average rate of fuel poverty either side of the border. However, in Wales, detached housing also has average rates, whereas due to higher incomes and higher SAP ratings, such housing in England has the lowest incidence of fuel poverty. In Wales, purpose built flats, with their small size and low external wall area, house the lowest proportion of fuel poor (25%).

3.8 With housing benefits excluded from incomes, purpose-built and converted flats move to second and third positions, after end-terraced housing, for the proportion of all households in fuel poverty in Wales, with converted flats now having the highest proportion (17%) of severe fuel poor. *(Table 3.5)*

Table 3.5: Fuel poverty in Wales and England by type of dwelling (full & basic incomes)

Thousand households/ *Row percentages*

Type of dwelling	Full income definition			Basic income definition			Total
by country	All households In fuel poverty		In severe FP	All households in fuel poverty		In severe FP	house-holds
	Thousands	*percent*	*percent*	thousands	*percent*	*percent*	thousands
WALES							
End terraced	47	*38.0*	*8.6*	50	*40.9*	*14.6*	123
Mid terraced	84	*31.3*	*4.8*	93	*34.5*	*9.8*	269
Semi-detached	121	*31.3*	*5.9*	129	*33.4*	*10.0*	386
Detached house	85	*29.9*	*7.1*	86	*30.0*	*7.5*	285
Converted flat etc.	5	*27.2*	*4.8*	6	*37.3*	*16.7*	17
Purpose built flat	19	*24.5*	*5.4*	30	*38.5*	*13.5*	78
Totals for Wales	**360**	***31.0***	***6.2***	**394**	***34.0***	***10.2***	**1157**
ENGLAND							
End terraced	570	*27.6*	*4.0*	695	*33.6*	*6.9*	2066
Mid terraced	875	*22.2*	*3.6*	1104	*28.0*	*5.8*	3944
Semi-detached	1313	*22.2*	*3.7*	1506	*25.5*	*5.2*	5902
Detached house	654	*16.1*	*2.9*	663	*16.3*	*2.9*	4068
Converted flat etc.	199	*23.5*	*2.7*	270	*31.9*	*9.5*	846
Purpose built flat	667	*23.7*	*2.0*	1028	*36.5*	*6.3*	2816
Totals for England	**4274**	***21.8***	***3.3***	**5241**	***26.7***	***5.4***	**19643**

3.9 Under the residual income definition, the order remains the same as for full income whether using the new 13% or traditional 10% threshold for fuel poverty. However, the range between the highest rate of fuel poverty in end terraced housing and lowest rate in purpose built flat increases significantly. The range under the residual definition (13% threshold) is from 40% to 21%, whereas under the full income definition, the range runs from 38% to 25%. There also appears to be a significant increase in the proportion of households in converted flats classed as severely fuel poor, but here the sample size is small. *(Table 3.6)*

Table 3.6: Fuel poverty in Wales by type of dwelling (equivalised residual incomes)

Thousand households/ *Row percentages*

Type of dwelling	Residual – new thresholds			Residual - normal thresholds			Total
	All households in fuel poverty		In severe FP	All households in fuel poverty		In severe FP	house-holds
	Thousands	*percent*	*percent*	thousands	*percent*	*percent*	thousands
End terraced	49	*39.6*	*7.6*	66	*53.8*	*20.8*	123
Mid terraced	90	*33.5*	*7.7*	123	*45.6*	*17.4*	269
Semi-detached	124	*32.1*	*5.9*	173	*44.9*	*16.2*	386
Detached house	79	*27.7*	*5.5*	117	*41.2*	*13.4*	285
Converted flat etc.	5	*27.1*	**10.7*	6	*38.7*	*17.1*	17
Purpose built flat	16	*20.9*	*2.9*	24	*31.2*	*8.3*	78
Totals	**362**	***31.3***	***6.3***	**510**	***44.1***	***15.8***	**1157**

* Sample cell size under 50

Dwelling size

3.10 Under the full income definition, there is no clear relationship in Wales between fuel poverty and dwelling size, no size showing markedly different rates from the average. While small homes tend to have smaller required fuel costs, they are more likely to be occupied by small households on low incomes, while many are older terraced dwellings with low SAP ratings. Conversely, while larger homes usually have higher fuel costs, they tend to be occupied by higher income groups and have higher SAP ratings. In England, these factors are more apparent, fuel poverty rates progressively declining as dwelling sizes increase. But with generally lower incomes, lower SAP ratings and more under-occupation, the same tendency is only evident in Wales under the basic income definition. *(Table 3.7)*

Table 3.7: Fuel poverty in Wales and England by dwelling size (full & basic incomes)

Thousand households/ *Row percentages*

Dwelling size by country	Full income definition			Basic income definition			Total
	All households In fuel poverty		In severe FP	All households in fuel poverty		In severe FP	house-holds
	Thousands	*percent*	*percent*	thousands	*percent*	*percent*	thousands
WALES							
Under 60 m^2	37	*30.7*	*7.1*	50	*41.3*	*15.8*	120
60 to 80 m^2	104	*33.0*	*5.2*	118	*37.5*	*12.4*	315
80 to 100 m^2	128	*30.6*	*5.2*	133	*31.8*	*7.8*	417
100 to 120 m^2	32	*32.0*	*7.2*	34	*33.1*	*9.0*	102
120 to 150 m^2	29	*26.8*	*7.3*	29	*26.9*	*7.6*	107
150 m^2 or more	31	*32.1*	*10.0*	31	*32.2*	*10.1*	96
Totals for Wales	**360**	***31.0***	***6.2***	**394**	***34.0***	***10.2***	**1157**
ENGLAND							
Under 60 m^2	817	*24.8*	*3.1*	1126	*34.1*	*6.1*	3301
60 to 80 m^2	1458	*23.5*	*2.8*	1866	*30.1*	*5.7*	6193

80 to 100 m^2	1071	*21.6*	*3.0*	1281	*25.8*	*5.2*	4962
100 to 120 m^2	391	*18.8*	*4.2*	415	*20.0*	*5.2*	2080
120 to 150 m^2	279	*17.6*	*4.7*	291	*18.3*	*5.2*	1587
150 m^2 or more	258	*16.9*	*3.2*	261	*17.2*	*3.2*	1521
Totals for England	**4274**	***21.8***	***3.3***	**5241**	***26.7***	***5.4***	**19643**

3.11 Compared to the estimates for the full and basic income definitions, the main effect of using equivalised residual incomes is to increase the rate of fuel poverty in larger homes relative to those in smaller ones. For example, in homes of under 60m^2, 31% of households would need to spend more than 10% of their full income on fuel, but only 24% would require over 13% of their residual incomes. However, in homes of 150 m^2 or more, the situation is reversed; the equivalent figures are 32% and 40% respectively. The effect is the same using the 10% and 20% thresholds with residual income. For example, the estimates for the smallest dwellings are below those produced by the basic income definition. However, the proportion of households in fuel poverty in the largest dwellings is substantially higher (53% compared to 32%). *(Table 3.8)*

Table 3.8: Fuel poverty in Wales by dwelling size (equivalised residual incomes)

Thousand households/ *Row percentages*

Dwelling size	Residual – new thresholds			Residual - normal thresholds			Total
	All households in fuel poverty		In severe FP	All households in fuel poverty		In severe FP	house-holds
	Thousands	*percent*	*percent*	thousands	*percent*	*percent*	thousands
Under 60 m^2	29	*24.0*	*4.3*	43	*35.3*	*11.0*	120
60 to 80 m^2	103	*32.6*	*6.8*	140	*44.5*	*17.1*	315
80 to 100 m^2	128	*30.7*	*5.8*	184	*44.0*	*15.4*	417
100 to 120 m^2	32	*31.6*	*6.1*	45	*44.7*	*15.1*	102
120 to 150 m^2	32	*29.7*	*6.9*	47	*44.3*	*14.4*	107
150 m^2 or more	38	*40.1*	*8.5*	51	*52.9*	*20.8*	96
Totals	**362**	***31.3***	***6.3***	**510**	***44.1***	***15.8***	**1157**

Main heating system

3.12 Although indicating very high levels of fuel poverty and severe fuel poverty, the sample of cases where there is no fixed heating is too small to give comparative results. In homes with individual fixed heaters but lacking central heating, the level of fuel poverty is over 45% in both countries. Households with central heating generally have much lower levels of fuel poverty, but nevertheless the proportion amongst such households in Wales (30%) is significantly higher than in England (18%). Although with generally higher estimates, the distribution pattern remains essentially the same when fuel poverty is calculated using basic incomes. *(Table 3.11)*

Table 3.11: Fuel poverty in Wales and England by heating system (full & basic incomes)

Thousand households/ *Row percentages*

Main heating system by country	Full income definition: All households in fuel poverty (thousands)	Full income definition: All households in fuel poverty (percent)	Full income definition: In severe FP (percent)	Basic income definition: All households in fuel poverty (thousands)	Basic income definition: All households in fuel poverty (percent)	Basic income definition: In severe FP (percent)	Total households (thousands)
WALES							
No fixed heating	1	*57.5*	*30.1*	1	*58.3*	*32.4*	3
Other fixed heating only	50	*46.3*	*13.0*	54	*50.1*	*17.9*	109
Central heating system	309	*29.5*	*5.4*	338	*32.3*	*9.3*	1046
Totals for Wales	**360**	***31.0***	***6.2***	**394**	***34.0***	***10.2***	**1157**
ENGLAND							
No fixed heating	61	*91.2*	*16.4*	61	*91.2*	*35.4*	67
Other fixed heating only	1064	*45.4*	*10.2*	1209	*51.6*	*17.0*	2341
Central heating system	3152	*18.3*	*2.3*	3974	*23.1*	*3.7*	17235
Totals for England	**4274**	***21.8***	***3.3***	**5241**	***26.7***	***5.4***	**19643**

3.13 While the correlation between fuel poverty and the general standard of the heating system is unchanged with the use of residual incomes, the gap between the proportion of homes with and without central heating that are classed as fuel poor and in severe fuel poverty is somewhat reduced. This trend is apparent using both the new and traditional income thresholds. *(Table 3.12)*

Table 3.12: Fuel poverty in Wales by main heating system (equivalised residual incomes)

Thousand households/ *Row percentages*

Main heating system	Residual – new thresholds: All households in fuel poverty (thousands)	Residual – new thresholds: All households in fuel poverty (percent)	Residual – new thresholds: In severe FP (percent)	Residual - normal thresholds: All households in fuel poverty (thousands)	Residual - normal thresholds: All households in fuel poverty (percent)	Residual - normal thresholds: In severe FP (percent)	Total households (thousands)
No fixed heating	1	*54.4*	*10.8*	2	*75.0*	*32.9*	3
Other fixed heating only	45	*41.5*	*9.5*	59	*54.4*	*22.9*	109
Central heating system	316	*30.2*	*5.9*	449	*42.9*	*15.0*	1046
Totals	**362**	***31.3***	***6.3***	**510**	***44.1***	***15.8***	**1157**

Main heating fuels

3.14 Households using solid fuel or LPG/bottled gas as their main heating fuel - of which there are a significantly higher proportion in Wales - have the highest levels of fuel poverty and severe fuel poverty in both Wales and England [5]. However, their rank order is reversed; 66% of Welsh households using solid fuel and 65% of English households using LPG/bottled gas are fuel poor. The next highest levels occur amongst households who rely on electricity for their main heating, this being true in both Wales and England.

Table 3.13: Fuel poverty in Wales and England by main heating fuel (full & basic incomes)

Thousand households/ *Row percentages*

Main heating fuel by country	Full income definition: All households in fuel poverty		Full income definition: In severe FP	Basic income definition: All households in fuel poverty		Basic income definition: In severe FP	Total house-holds
	thousands	*percent*	*percent*	thousands	*percent*	*percent*	thousands
WALES							
Solid fuel	74	*65.6*	*22.5*	74	*66.3*	*27.3*	112
Lpg/bottled gas	12	*56.9*	*15.5*	12	*57.1*	*15.9*	21
Electric heating	28	*39.4*	*10.9*	31	*42.5*	*16.4*	72
Fuel oil	20	*27.5*	*5.4*	20	*28.1*	*5.9*	71
Mains gas	223	*25.6*	*3.3*	253	*28.9*	*7.4*	873
Communal heating	1	*12.4*	*1.8*	1	*28.7*	*6.5*	5
No fixed heating	1	*57.5*	*30.1*	1	*58.3*	*32.4*	3
Totals for Wales	**359**	***31.0***	***6.2***	**394**	***34.0***	***10.0***	**1157**
ENGLAND							
Solid fuel	320	*49.4*	*12.3*	339	*52.3*	*18.4*	648
Lpg/bottled gas	44	*64.8*	*12.7*	44	*64.8*	*12.7*	69
Electric heating	708	*34.2*	*8.8*	825	*39.8*	*12.4*	2071
Fuel oil	84	*15.6*	*3.5*	87	*16.1*	*3.7*	541
Mains gas	2995	*18.8*	*2.1*	3808	*23.9*	*3.8*	15928
Communal heating *	n.a.			n.a.			229
No fixed heating	61	*91.2*	*16.4*	61	*91.2*	*35.4*	67
Totals for England	**4274**	***21.8***	***3.3***	**5241**	***26.7***	***5.4***	**19643**

* The 1996 EHCS fuel poverty model does not provide estimates for communally heated dwellings

3.15 In Wales, households with communal heating have the lowest levels of fuel poverty (12%). In England, where comparable estimates are not available, the lowest position is taken by households using fuel oil (16%). Mains gas, as used by three quarters of the households in Wales and over fourth fifths of those in England, holds the next lowest position, with a quarter of these particular households in Wales and under a fifth in England living in fuel poverty. However, the basic income definition substantially increases the proportion of fuel poor amongst households using communal heating and, to a lesser, extent amongst those using gas. Gas users now exhibit higher rates of fuel poverty than households using fuel oil. *(Table 3.13)*

[5] Excluding the small sample of cases of no fixed heating.

3.16 As with heating systems, the order in the rates of fuel poverty for different heating fuels remains the same for the residual income definition as that for full income. As elsewhere, however, the use of the new threshold with equivalised residual incomes tends to reduce the differences between the various fuel categories. *(Table 3.14)*

Table 3.14: Fuel poverty in Wales by main heating fuel (equivalised residual incomes)

Thousand households/Row percentages

Main heating fuel	Residual – new thresholds			Residual - normal thresholds			Total
	All households in fuel poverty		In severe FP	All households in fuel poverty		In severe FP	house-holds
	thousands	*percent*	*percent*	thousands	*percent*	*percent*	thousands
Solid fuel	72	*63.7*	*16.4*	87	*77.3*	*37.4*	112
Lpg/bottled gas	12	*55.6*	*10.6*	15	*70.5*	*31.0*	21
Electric heating	23	*32.5*	*8.2*	32	*44.1*	*18.5*	72
Fuel oil	20	*28.0*	*4.3*	31	*43.3*	*11.9*	71
Mains gas	233	*26.6*	*4.8*	341	*39.1*	*12.5*	873
Communal heating *	0	*10.1*	*2.5*	1	*21.3*	*6.4*	5
No fixed heating	1	*55.6*	*12.7*	2	*80.4*	*30.4*	3
Totals	**362**	***31.3***	***6.3***	**510**	***44.1***	***15.8***	**1157**

SAP ratings

3.17 In both Wales and England, the overall incidence of fuel poverty progressively decreases as the SAP rating improves. In Wales, 66% of households living in highly inefficient dwellings with ratings under 10 are in fuel poverty, compared to only 7% of households in dwellings rated 65 or more. However, in all SAP bands the frequency is higher in Wales than in England and this can be attributed to the other causal factors of low income, high fuel prices, under-occupancy and dwelling size. Because of these other factors and despite the strong correlation with SAP ratings, the largest number of households in fuel poverty in both Wales and England are found in the bulk of housing of average energy efficiency.

3.18 The importance of these other factors, can be further seen by the fact that 1% of households remain in severe fuel poverty even in homes with SAP ratings of 65 or more. Nevertheless, the frequency of severe fuel poverty improves dramatically with increasing energy efficiency, falling in Wales from 26% in the least efficient dwellings to under 3% in homes with above average SAP ratings. The strong correlation between fuel poverty and SAP ratings is maintained under the basic income definition, although the percentage classed as fuel poor tends to increase more in higher energy rated homes than in those of poor energy efficiency. *(Table 3.15)*

Table 3.15: Fuel poverty in Wales and England by SAP rating (full & basic incomes)

Thousand households/ *Row percentages*

SAP rating by country	Full income definition: All households in fuel poverty		Full income definition: In severe FP	Basic income definition: All households in fuel poverty		Basic income definition: In severe FP	Total house-holds
	thousands	*percent*	*percent*	thousands	*percent*	*percent*	thousands
WALES							
SAP under 10	56	*65.6*	*26.0*	56	*66.1*	*30.0*	85
10 to 20	38	*54.0*	*13.9*	39	*54.7*	*18.5*	71
20 to 30	39	*46.3*	*11.8*	41	*49.0*	*17.0*	83
30 to 40	78	*37.0*	*5.6*	83	*39.6*	*10.7*	211
40 to 50	104	*26.0*	*2.9*	114	*28.6*	*6.4*	398
50 to 65	39	*17.6*	*2.3*	46	*20.8*	*6.0*	222
SAP 65 or more	7	*8.1*	*1.1*	15	*16.9*	*3.9*	87
Totals for Wales	**360**	***31.0***	***6.2***	**394**	***34.0***	***10.2***	**1157**
ENGLAND							
SAP under 10	473	*54.0*	*24.4*	494	*56.4*	*29.6*	877
10 to 20	410	*55.3*	*10.7*	426	*57.4*	*20.8*	742
20 to 30	720	*43.9*	*6.1*	780	*47.5*	*11.5*	1641
30 to 40	1090	*28.1*	*2.6*	1269	*32.7*	*5.1*	3876
40 to 50	946	*16.6*	*1.8*	1224	*21.5*	*2.8*	5692
50 to 65	565	*10.5*	*0.8*	880	*16.3*	*1.7*	5392
SAP 65 or more	75	*5.3*	*0.0*	173	*12.2*	*0.5*	1423
Totals for England	**4274**	***21.8***	***3.3***	**5241**	***26.7***	***5.4***	**19643**

3.19 The use of the residual income definition maintains the strong correlation between energy efficiency and fuel poverty, albeit reducing the range when measured using the 13% threshold. Thus, due to low incomes and/or large homes, 13% of households living in housing with SAP ratings of 65 or more would still live in fuel poverty, using the 13% threshold. The comparable figure using the 10% threshold is 20%. Nevertheless, these proportions are still substantially lower than the 62% of households (13% threshold) and 75% of households (10% threshold) who live in fuel poverty in the least energy efficient stock. *(Table 3.16)*

Table 3.16: Fuel poverty in Wales by SAP ratings (equivalised residual incomes)

Thousand households/Row percentages

SAP rating	Residual – new thresholds			Residual - normal thresholds			Total
	All households in fuel poverty		In severe FP	All households in fuel poverty		In severe FP	house-Holds
	thousands	*percent*	*percent*	thousands	*percent*	*percent*	Thousands
SAP under 10	53	*62.2*	*17.3*	64	*75.2*	*37.6*	85
10 to 20	35	*49.5*	*12.6*	46	*64.2*	*29.2*	71
20 to 30	36	*42.8*	*9.7*	48	*57.4*	*23.7*	83
30 to 40	75	*35.6*	*6.7*	106	*50.1*	*16.9*	211
40 to 50	103	*25.8*	*4.2*	157	*39.5*	*11.7*	398
50 to 65	49	*22.2*	*3.9*	73	*32.6*	*10.3*	222
SAP 65 or more	11	*12.9*	*1.5*	17	*19.5*	*5.5*	87
Totals	**362**	***31.3***	***6.3***	**510**	***44.1***	***15.8***	**1157**

Housing conditions

3.20 As with energy efficiency, in both Wales and England the level of fuel poverty falls as housing conditions improve. In Wales, 47% of households living in unfit dwellings [6] are fuel poor and 13% are in severe fuel poverty. The equivalent figures for those in satisfactory dwellings are 26% and 4%. In England, the incidence of fuel poverty falls from 36% for households in unfit housing to 17% for households in satisfactory housing. Similarly, 7% of households in unfit dwellings live in severe fuel poverty, compared to 3% of households in satisfactory ones. The distribution pattern stays roughly the same under the basic income definition, albeit with increased percentages. *(Table 3.17)*

[6] The Fitness Standard is defined by section 604 of the Housing Act 1985 as amended by schedule 9 of the 1989 Local Government and Housing Act. Under this Standard, a dwelling-house is fit for human habitation unless it fails to meet one or more of the requirements below and, by reason of that failure, is not reasonably suitable for occupation:-

a) it is structurally stable;
b) it is free from serious disrepair;
c) it is free from dampness prejudicial to health of the occupants (if any);
d) it has adequate provision for lighting, heating and ventilation;
e) it has an adequate piped supply of wholesome water;
f) there are satisfactory facilities in the dwelling-house for the preparation and cooking of food, including a sink with a satisfactory supply of hot and cold water;
g) it has a suitably located water-closet for the exclusive use of occupants (if any);
h) it has for the exclusive use of the occupants (if any) a suitably located bath or shower and wash-hand basin, each of which is provided with a satisfactory supply of hot and cold water; and
i) it has an effective system for the draining of foul, waste and surface water;

Additionally, a dwelling-house which is a flat is unfit for human habitation if the building or part of the building outside the flat fails to meet one or more of the requirements below and, by reason of that failure, the flat is not reasonably suitable for occupation:-

a) the building or part is structurally stable;
b) it is free from serious disrepair;
c) it is free from dampness;
d) it has adequate provision for ventilation; and
e) it has an effective system for the draining of foul, waste and surface water.

Table 3.17: Fuel poverty in Wales and England by housing condition (full & basic incomes)

Thousand households/ *Row percentages*

Housing conditions by country	Full income definition			Basic income definition			Total
	All households in fuel poverty		In severe FP	All households in fuel poverty		In severe FP	house-holds
	thousands	*percent*	*percent*	thousands	*percent*	*percent*	thousands
WALES							
Unfit	44	*47.3*	*12.9*	46	*49.4*	*17.8*	93
Defective/ just adequate	194	*32.7*	*6.7*	208	*35.1*	*11.2*	594
Satisfactory	123	*26.1*	*4.2*	140	*29.7*	*7.3*	471
Totals for Wales	**360**	***31.0***	***6.2***	**394**	***34.0***	***10.2***	**1157**
ENGLAND							
Unfit	463	*36.4*	*6.5*	554	*43.5*	*12.1*	1272
Defective/ just adequate	1993	*25.9*	*3.7*	2436	*31.6*	*6.4*	7702
Satisfactory	1819	*17.1*	*2.5*	2254	*21.1*	*3.8*	10669
Totals for England	**4274**	***21.8***	***3.3***	**5241**	***26.7***	***5.4***	**19643**

3.21 The relationship between housing conditions and fuel poverty is largely unchanged by the use of equivalised residual incomes , although the divergence between the rates for unfit and satisfactory housing is somewhat reduced as with other variables. Using the 13% and 31.5% thresholds, 45% of all households in unfit dwellings are in fuel poverty and 12% are in severe fuel poverty. *(Table 3.18)*

Table 3.18: Fuel poverty in Wales by housing condition (Equivalised residual incomes)

Thousand households/Row percentages

Main heating system	Residual – new thresholds			Residual - normal thresholds			Total
	All households in fuel poverty		In severe FP	All households in fuel poverty		In severe FP	house-holds
	thousands	*percent*	*percent*	thousands	*percent*	*percent*	thousands
Unfit	41	*44.6*	*11.6*	53	*57.4*	*25.1*	93
Defective/ just adequate	203	*34.2*	*7.1*	281	*47.4*	*17.5*	594
Satisfactory	118	*25.0*	*4.2*	175	*37.2*	*11.7*	471
Totals	**362**	***31.3***	***6.3***	**510**	***44.1***	***15.8***	**1157**

PART 4: FUEL POVERTY IN THE HOUSEHOLD POPULATION

Vulnerable households

4.1 In the UK Fuel Poverty Strategy, vulnerable households are defined as those with a person aged 60 years or over, a child under the age of 16 and/or a person who is disabled or has a long term illness. With a higher proportion of older occupants and those ill or disabled, Wales has a greater proportion of vulnerable households (71%) than England (67%), but a comparable proportion to Merseyside (70%). *(Table 4.1)*

Table 4.1: Vulnerable households in Wales, England and three English regions

Thousands/Column percentages

Vulnerable households	Wales 1997/98		England and 1996	Merseyside	North East	Yorks & Humber
	x1000	Col %				
With person 60 years or over	415	35.8	34.2	33.5	33.8	35.1
With ill or disabled (16-59 yrs) [7]	55	4.7	3.4	5.8	3.1	4.0
With under 16 yrs (all < 60 yrs)	346	29.9	29.4	31.1	30.2	26.0
Not vulnerable	341	29.5	33.0	29.6	32.9	34.9
Total vulnerable households	816	70.5	67.0	70.4	67.1	65.1
Totals	**1157**	**100**	**100.0**	**100**	**100**	**100**

4.2 Under the full income definition, households that include a person aged 60 years or over are most likely to live in fuel poverty (45%) and in severe fuel poverty (9%). Such households account for 52% of all fuel poor households in Wales. Households that include members that are ill or disabled, but have no person aged 60 years or over or under 16 years, have the second highest incidence of fuel poverty (39%). In total, 38% of all vulnerable households are fuel poor compared with 14% of non-vulnerable households.

4.3 In England, the distribution is significantly different. Households with members that are ill or disabled have the highest level of fuel poverty (39%) and those that are vulnerable because they have children under the age of 16 years, have the least (12%). This rate is lower than the rate (15%) for non-vulnerable households on the full income definition. Under the basic income definition, however, these two lowest positions are reversed in England. In Wales, households with members that are ill or disabled record the highest proportion (14%) of severe fuel poverty (basic income definition). *(Table 4.2)*

[7] In Wales, ill and disabled households are taken as those reporting receipt of an incapacity benefit or industrial injury disablement benefit in the 1997/98 WHCS, but in England where the 1996 EHCS collected a wider range of benefit data a slightly wider definition is used.

Table 4.2: Fuel poverty in Wales & England by vulnerable household (full & basic incomes)

Thousand households/ *Row percentages*

Vulnerable household by country	Full income definition: All households in fuel poverty		Full income definition: In severe FP	Basic income definition: All households in fuel poverty		Basic income definition: In severe FP	Total house-holds
	thousands	*percent*	*percent*	thousands	*percent*	*percent*	thousands
WALES							
Person 60 years or over	188	*45.4*	*9.3*	204	*49.1*	*13.1*	415
Ill or disabled (16-59)	21	*39.1*	*7.5*	24	*43.3*	*14.3*	55
Other under 16 years	104	*29.9*	*5.3*	116	*33.5*	*11.7*	346
Not vulnerable	47	*13.8*	*3.0*	50	*14.7*	*4.3*	341
Total vulnerable	313	*38.4*	*7.5*	344	*42.1*	*12.6*	816
Totals for Wales	**360**	***31.0***	***6.2***	**394**	***34.0***	***10.2***	**1157**
ENGLAND							
Person 60 years or over	2381	*35.4*	*4.5*	2751	*40.9*	*5.7*	6723
Ill or disabled (16-59)	257	*39.1*	*7.8*	334	*50.8*	*18.2*	658
Other under 16 years	676	*11.7*	*0.6*	1039	*18.0*	*1.9*	5772
Not vulnerable	971	*15.0*	*3.9*	1130	*17.4*	*6.8*	6490
Total vulnerable	3314	*25.1*	*2.9*	4124	*31.3*	*4.6*	13153
Totals for England	**4274**	***21.8***	***3.3***	**5241**	***26.7***	***5.4***	**19643**

4.4 In contrast to most of the distributions for the housing variables, using equivalised residual incomes has a profound effect on the ranking of the types of vulnerable household most likely to be classed as fuel poor in Wales. Under this definition, the first and third positions occupied by households with persons aged 60 years or older and those with children under the age of 16 years, but no elderly persons, are reversed. However, 'ill and disabled' households remain in second place and non-vulnerable households still have the lowest rate (now 17%). Although with substantially larger estimates, the new ranking is the same for the traditional thresholds as for the new thresholds, and also holds true for severe fuel poverty as well as for all fuel poverty. *(Table 4.3)*

Table 4.3: Fuel poverty in Wales by vulnerable household (equivalised residual incomes)

Thousand households/ *Row percentages*

Vulnerable household	Residual – new thresholds			Residual - normal thresholds			Total
	All households in fuel poverty		In severe FP	All households in fuel poverty		In severe FP	house-holds
	thousands	*percent*	*percent*	thousands	*percent*	*percent*	thousands
Person under 16 years	164	*47.3*	*12.0*	210	*60.5*	*27.7*	346
Ill or disabled (16-59 yrs)	23	*42.2*	*8.0*	30	*55.2*	*22.4*	55
Person 60 years or over	118	*28.4*	*3.7*	183	*44.2*	*11.3*	415
Not vulnerable	57	*16.8*	*3.3*	87	*25.4*	*8.0*	341
Total vulnerable	305	*37.4*	*7.5*	423	*51.9*	*19.0*	816
Totals	**362**	***31.3***	***6.3***	**510**	***44.1***	***15.8***	**1157**

Household type

4.5 There are significant differences between the distribution of fuel poverty amongst different household types between Wales and England. In Wales, lone parents have the highest level of fuel poverty. Nearly two thirds of lone parents live in fuel poverty compared to one third in England. Single person households aged 60 years or over have the next highest proportion of fuel poverty (57%), whereas in England these represent the largest group of fuel poor at 52%. Moreover, in Wales, both groups have 14% of households in severe fuel poverty.

4.6 In both Wales and England, single person households under the age of 60 are the third highest group, with 27% and 31% respectively living in fuel poverty. In both countries, households with dependent children and other households without dependent children are the least likely to live in fuel poverty, although for both groups the incidence is significantly higher in Wales. However, all three groups have fewer than 10% of households in severe fuel poverty.

4.7 The basic income definition produces the same distribution pattern, but substantially increases the rates, particularly for lone parents. Around 73% of lone parents are now classed as fuel poor, including 36% who are in severe fuel poverty. For Wales, it is estimated that 47% of all lone parents were in receipt of housing benefit in 1997/98, compared to 25% of single persons aged 60 years or over and under 13% for each of the remaining household types. *(Table 4.4)*

Table 4.4: Fuel poverty in Wales and England by household type (full & basic incomes)

Thousand households/ *Row percentages*

Household type by country	Full income definition: All households in fuel poverty		Full income definition: In severe FP	Basic income definition: All households in fuel poverty		Basic income definition: In severe FP	Total house-holds
	thousands	*percent*	*percent*	thousands	*percent*	*percent*	thousands
WALES							
Lone parent households	47	*64.6*	*13.7*	53	*72.9*	*35.9*	73
Single person >= 60 yrs	101	*57.0*	*13.8*	111	*62.8*	*20.7*	177
Single person < 60 yrs	24	*26.9*	*7.9*	26	*29.2*	*13.1*	88
No dependent children	122	*24.0*	*3.9*	130	*25.6*	*5.2*	508
With dependent children	67	*21.5*	*3.3*	74	*23.7*	*5.4*	311
Totals for Wales	**360**	***31.0***	***6.2***	**394**	***34.0***	***10.2***	**1157**
ENGLAND							
Lone parent households	425	*33.5*	*1.4*	713	*56.2*	*6.4*	1268
Single person >= 60 yrs	1598	*51.8*	*7.3*	1868	*60.6*	*9.4*	3083
Single person < 60 yrs	705	*30.8*	*9.6*	852	*37.2*	*17.5*	2291
No dependent children	1316	*16.4*	*2.1*	1490	*18.6*	*3.3*	8013
With dependent children	255	*5.1*	*0.2*	349	*7.0*	*0.4*	4987
Totals for England	**4274**	***21.8***	***3.3***	**5241**	***26.7***	***5.4***	**19643**

4.8 For household types, the use of equivalised residual incomes again changes the distribution quite substantially. While lone parents remain 'on top' with the highest rate in Wales (68%), other households with dependent children change from having the lowest rate of fuel poverty, under the full and basic income definitions, to having the second highest rate using residual incomes. Around 22% of households with dependent children live in fuel poverty on the full income definition, while 43% of these households live in fuel poverty on the 13% threshold (56%, using the 10% threshold). Moreover, couples and larger households without dependent children come third, leaving single person households aged sixty years or more and those aged under 60 years with the lowest rates of fuel poverty and severe fuel poverty, when measured using either the new or existing income thresholds. *(Table 4.5)*

Table 4.5: Fuel poverty in Wales by household type (equivalised residual incomes)

Thousand households/ *Row percentages*

Vulnerable household	Residual – new thresholds			Residual - normal thresholds			Total
	All households in fuel poverty		In severe FP	All households in fuel poverty		In severe FP	house-holds
	thousands	*percent*	*Percent*	thousands	*percent*	*percent*	thousands
Lone parent households	49	*67.5*	*20.6*	58	*80.3*	*45.3*	73
Single person>= 60 yrs	38	*21.4*	*1.9*	61	*34.6*	*7.3*	177
Single person< 60 yrs	12	*14.1*	*3.2*	18	*20.5*	*7.6*	88
No dependent children	130	*25.7*	*4.2*	198	*38.9*	*11.4*	508
With dependent children	132	*42.5*	*9.6*	174	*56.1*	*23.1*	311
Totals	**362**	***31.3***	***6.3***	**510**	***44.1***	***15.8***	**1157**

Age of oldest occupant

4.9 Table 4.6 shows the incidence of fuel poverty by the age of the oldest person in the household, and includes, for example, elderly relatives living with younger families. The youngest households have high levels of fuel poverty; 37% live in fuel poverty in Wales and 40% in England (full income definition). Slightly older households tend to have lower rates, particularly in England. The lowest frequencies are found in both countries in households where the oldest person is aged under 60 years.

4.10 For people aged 60 years and over, fuel poverty progressively increases in frequency. Households with the oldest occupants have the highest rates. In Wales, a half of households with persons aged 75 years or over live in fuel poverty and 12% are in severe fuel poverty. However, in England such high rates are generally found only in households with persons aged 85 or more. The use of basic incomes has comparatively little effect on the overall pattern for the age distribution of fuel poverty, although it does increase the overall rate and severity of fuel poverty, particularly for younger households. *(Table 4.6)*

Table 4.6: Fuel poverty in Wales and England by oldest occupant (full & basic incomes)

Thousand households/ *Row percentages*

Oldest occupant by country	Full income definition: All households in fuel poverty		Full income definition: In severe FP	Basic income definition: All households in fuel poverty		Basic income definition: In severe FP	Total households
	thousands	*percent*	*percent*	thousands	*percent*	*percent*	thousands
WALES							
Under 25 years	11	*37.0*	*9.1*	13	*43.4*	*21.6*	29
25 years to 34 years	47	*26.9*	*4.6*	53	*30.6*	*11.4*	174
35 years to 49 years	71	*21.4*	*4.1*	79	*23.6*	*7.3*	334
50 years to 59 years	43	*21.1*	*4.1*	45	*22.1*	*6.1*	205
60 years to 74 years	114	*42.7*	*7.9*	122	*45.9*	*11.3*	266
75 years to 84 years	57	*49.5*	*12.2*	63	*54.9*	*17.2*	115
85 years or over	18	*52.6*	*11.0*	18	*54.9*	*13.8*	34
Totals for Wales	**360**	***31.1***	***6.2***	**394**	***34.0***	***10.2***	**1157**
ENGLAND							
Under 25 years	296	*39.9*	*13.9*	420	*56.7*	*21.9*	740
25 years to 34 years	457	*12.7*	*1.1*	709	*19.7*	*3.2*	3599
35 years to 49 years	653	*11.7*	*1.6*	793	*14.2*	*3.9*	5597
50 years to 59 years	498	*16.7*	*3.5*	581	*19.5*	*5.8*	2984
60 years to 74 years	1343	*30.8*	*3.5*	1552	*35.6*	*4.6*	4357
75 years to 84 years	789	*42.1*	*5.1*	901	*48.0*	*6.7*	1875
85 years or over	253	*51.7*	*11.4*	303	*61.9*	*12.7*	490
Totals for England	**4274**	***21.8***	***3.3***	**5241**	***26.7***	***5.4***	**19643**

4.11 As with household types, the effect of using equivalised incomes is more dramatic. In contrast to the position using full and basic incomes, younger households show the highest rates of fuel poverty and severe fuel poverty using both the new and traditional thresholds. Albeit with some increase with advanced age, households where the oldest occupant is 60 years or over generally have average or below average levels of fuel poverty and/or severe fuel poverty. *(Table 4.7)*

Table 4.7: Fuel poverty in Wales by Oldest occupant (equivalised residual incomes)

Thousand households/ *Row percentages*

Oldest occupant	Residual – new thresholds: All households in fuel poverty		Residual – new thresholds: In severe FP	Residual - normal thresholds: All households in fuel poverty		Residual - normal thresholds: In severe FP	Total households
	thousands	*percent*	*percent*	thousands	*percent*	*percent*	thousands
Under 25 years	14	*49.0*	*17.0*	18	*59.6*	*33.1*	29
25 years to 34 years	59	*33.9*	*8.9*	75	*43.3*	*20.8*	174
35 years to 49 years	117	*35.1*	*8.5*	158	*47.3*	*19.6*	334
50 years to 59 years	54	*26.2*	*4.0*	76	*37.1*	*11.8*	205
60 years to 74 years	74	*27.9*	*3.8*	116	*43.6*	*11.0*	266
75 years to 84 years	33	*28.9*	*3.3*	51	*44.1*	*11.4*	115
85 years or over	10	*30.4*	*4.9*	17	*49.2*	*12.6*	34
Totals	**362**	***31.3***	***6.3***	**510**	***44.1***	***15.8***	**1157**

Household size

4.12 In Wales, the distribution of fuel poverty by household size shows a similar pattern to that in England when measured using full incomes. In both countries, single person households are the most likely to live in fuel poverty; 47% are fuel poor in Wales and 43% in England. As household size increases, the level of fuel poverty decreases. Four person households have the lowest proportion of fuel poverty in both countries. However, the decline is less in Wales than in England. Around 21% of 4 person households live in fuel poverty in Wales and 7% in England. Above four persons, fuel poverty increases with household size, particularly in Wales. Around 44% of households containing six or more persons live in fuel poverty in Wales, compared to 13% of such households in England.

4.13 A similar picture emerges when the data is analysed using the basic income definition, although the number of households classed as fuel poor or severely fuel poor increases for all sizes of household. *(Table 4.8)*

Table 4.8: Fuel poverty in Wales and England by household size (full & basic incomes)

Thousand households/ *Row percentages*

Household size	Full income definition			Basic income definition			Total
by country	All households in fuel poverty		In severe FP	All households in fuel poverty		In severe FP	house-holds
	thousands	*percent*	*percent*	thousands	*percent*	*percent*	thousands
WALES							
Single person	124	*46.9*	*11.8*	137	*51.6*	*18.2*	265
Two persons	109	*28.5*	*4.8*	119	*31.0*	*7.5*	384
Three persons	55	*25.8*	*4.8*	60	*28.1*	*9.1*	214
Four persons	40	*20.5*	*3.4*	43	*22.1*	*6.2*	195
Five persons	20	*27.5*	*4.3*	22	*30.1*	*7.6*	74
Six persons or more	11	*44.2*	*6.1*	12	*48.7*	*12.2*	25
Totals for Wales	**360**	***31.1***	***6.2***	**394**	***34.0***	***10.2***	**1157**
ENGLAND							
Single person	2299	*42.8*	*8.3*	2715	*50.5*	*12.9*	5374
Two persons	1253	*18.6*	*1.7*	1517	*22.5*	*3.4*	6739
Three persons	417	*12.8*	*1.4*	587	*17.9*	*2.8*	3271
Four persons	199	*6.9*	*0.6*	269	*9.3*	*0.7*	2891
Five persons	74	*7.6*	*1.2*	109	*11.1*	*1.7*	977
Six persons or more	52	*13.4*	*1.6*	69	*17.6*	*1.7*	391
Totals for England	**4274**	***21.8***	***3.3***	**5241**	***26.7***	***5.4***	**19643**

4.14 Since equivalisation takes household size into account, the effect of using the residual income definitions is particularly marked when analysing fuel poverty by household size. Using the unequivalised full and basic incomes, there is a clear tendency for the rate of fuel poverty to fall with increasing household size, rising only in households of five and six or more persons. However, the proportion of households in fuel poverty and in severe fuel poverty increase progressively from respectively 19% and 2% in single person households to 80% and 36% in households of six or more persons under the residual income definition (13% and

31.5% thresholds). The same increase is apparent under the traditional 10% and 20% thresholds. The equivalent figures for the smallest households are 30% and 8% and for the largest, 90% and 63% respectively.

Table 4.9: Fuel poverty in Wales by household size (equivalised residual incomes)

Thousand households/ *Row percentages*

Household size	Residual – new thresholds			Residual - normal thresholds			Total
	All households in fuel poverty		In severe FP	All households in fuel poverty		In severe FP	house-holds
	thousands	*percent*	*percent*	thousands	*percent*	*percent*	thousands
Single person	50	*19.0*	*2.3*	79	*30.0*	*7.5*	265
Two persons	90	*23.3*	*3.4*	141	*36.6*	*9.8*	384
Three persons	76	*35.5*	*7.2*	102	*47.8*	*18.3*	214
Four persons	79	*40.3*	*8.7*	107	*55.1*	*21.2*	195
Five persons	47	*63.7*	*16.4*	58	*77.5*	*38.6*	74
Six persons or more	20	*80.2*	*36.0*	23	*90.0*	*62.5*	25
Totals	**362**	***31.3***	***6.3***	**510**	***44.1***	***15.8***	**1157**

Household income

4.15 This section explores the correlation between fuel poverty and the income of households. As would be expected, fuel poverty is strongly correlated with household income. However, the precise strength of the correlation varies with the definition of fuel poverty used and its compatibility with the particular income measure under consideration. The varying distributions for two income measures, un-equivalised full income and equivalised residual income, are discussed below.

Full income (un-equivalised)

4.16 Examining full income under the 'full' income definition, fuel poverty is largely confined to the lowest two income quintiles in England. Here, 76% and 26% of households are fuel poor, compared with only 7% of those on average incomes. In Wales, however, with its generally lower national incomes, poorer energy efficiency and higher fuel costs, the equivalent figures for the two lowest quintiles are 79% and 44% respectively, with a further 22% of average income households living in fuel poverty. Severe fuel poverty is also more widely distributed in Wales, although in both countries easily the highest frequencies (22% in Wales and 15% in England) occur amongst households on the lowest incomes.

4.17 The already strong correlation between fuel poverty and full income increases with the use of the basic income definition. As would be expected, the fuel poverty rates of those on above average incomes remain largely unchanged. However, the proportions of households in the lowest income group in fuel poverty and in severe fuel poverty increases to 85% and 39% respectively. *(Table 4.10)*

Table 4.10: Fuel poverty in Wales and England by full income (full & basic incomes defn.)

Thousand households/ *Row percentages*

Full income (un-equivalised)	Full income definition			Basic income definition			Total
	All households in fuel poverty		In severe FP	All households in fuel poverty		In severe FP	house-holds
	thousands	*percent*	*percent*	thousands	*percent*	*percent*	thousands
WALES							
Lowest quintile	183	*78.8*	*22.2*	198	*85.4*	*38.7*	231
Second quintile	105	*45.2*	*5.7*	120	*52.0*	*8.8*	231
Middle quintile	50	*21.8*	*1.8*	52	*22.7*	*2.1*	231
Fourth quintile	15	*6.6*	*0.5*	16	*6.7*	*0.6*	231
Highest quintile	7	*3.1*	*0.6*	7	*3.1*	*0.6*	231
Totals for Wales	**360**	***31.0***	***6.2***	**394**	***34.0***	***10.2***	**1157**
ENGLAND							
Lowest quintile	2972	*75.6*	*15.2*	3381	*86.1*	*23.4*	3929
Second quintile	1031	*26.2*	*1.2*	1505	*38.3*	*3.5*	3929
Middle quintile	275	*7.0*	*0.1*	361	*9.2*	*0.4*	3929
Fourth quintile	53	*1.4*	*0.0*	61	*1.6*	*0.0*	3929
Highest quintile	5	*0.1*	*0.0*	5	*0.1*	*0.0*	3929
Totals for England	**4274**	***21.8***	***3.3***	**5241**	***26.7***	***5.4***	**19643**

4.18 In contrast, the correlation between levels of fuel poverty and (un-equivalised) full incomes is weakened when equivalised residual income is used in the fuel poverty definition. Thus, fuel poverty rates under the full income definition range from 79% for those in the lowest income quintile to 3% for those in the highest quintile. However, the range reduces from 55% (lowest quintile) to 9% (highest quintile), when the residual income definition (with the 13% threshold) is used. If the 10% threshold is used, the fuel poverty rate ranges from 71% (lowest quintile) to 16% (highest quintile). *(Table 4.11)*

Table 4.11: Fuel poverty in Wales by full income (equivalised residual income definition)

Thousand households/ *Row percentages*

Full income (un-equivalised)	Residual – new thresholds			Residual - normal thresholds			Total
	All households in fuel poverty		In severe FP	All households in fuel poverty		In severe FP	house-holds
	thousands	*percent*	*percent*	thousands	*percent*	*percent*	thousands
Lowest quintile	129	*55.4*	*16.4*	164	*70.6*	*34.2*	231
Second quintile	99	*42.7*	*8.5*	133	*57.5*	*22.4*	231
Middle quintile	78	*33.6*	*4.1*	111	*48.0*	*13.8*	231
Fourth quintile	37	*15.9*	*1.3*	65	*27.8*	*5.3*	231
Highest quintile	20	*8.7*	*1.0*	37	*16.3*	*3.1*	231
Totals	**362**	***31.3***	***6.3***	**510**	***44.1***	***15.8***	**1157**

Equivalised residual income

4.19 The weaker correlation shown above between the equivalised residual income definition of fuel poverty and full income, compared to that using the full and basic income definitions, arises because full income is not equivalised. The reverse is the case when the different income definitions for fuel poverty are cross-tabulated with equivalised residual incomes.[8]

4.20 Under the full income definition, 68% of households in the lowest quintile of equivalised residual incomes are in fuel poverty, compared to 28% of households in the middle quintile. The equivalent figures for the basic income definition are 75% and 30% respectively. For both of these definitions, the proportion of fuel poor in the lowest quintile is lower than shown in Table 4.10 above, while the proportion falling in the middle quintile is higher, thus demonstrating the weaker correlation than for un-equivalised full income. *(Table 4.12)*

Table 4.12: Fuel poverty in Wales by residual income (full & basic income definitions)

Thousand households/ *Row percentages*

Residual income (equivalised)	Full income definition			Basic income definition			Total
	All households in fuel poverty		In severe FP	All households in fuel poverty		In severe FP	house-holds
	thousands	*percent*	*percent*	thousands	*percent*	*percent*	thousands
Lowest quintile	156	*67.5*	*17.1*	174	*75.3*	*32.9*	231
Second quintile	98	*42.3*	*7.5*	109	*47.2*	*11.1*	231
Middle quintile	65	*28.2*	*3.9*	69	*29.8*	*4.3*	231
Fourth quintile	27	*11.8*	*1.5*	28	*12.0*	*1.5*	231
Highest quintile	14	*5.9*	*0.9*	14	*5.9*	*0.9*	231
Totals	**360**	***31.0***	***6.2***	**394**	***34.0***	***10.2***	**1157**

4.21 In contrast, using the residual income definition, the correlation between fuel poverty and equivalised residual incomes is particularly strong. On this definition and using the 13% threshold, 84% of households in the lowest quintile of equivalised residual incomes live in fuel poverty and over 80% of all fuel poor households fall in the lowest two income quintiles. Using the 10% of income thresholds, 93% of those in the lowest quintile are fuel poor. With either threshold, by limiting income to only that available to be spent on fuel, the use of an 'after housing costs' definition of fuel poverty strengthens the correlation between fuel poverty and income. *(Table 4.13)*

[8] As equivalised incomes are not readily available for England, no English comparisons are included in this sub-section

Table 4.13: Fuel poverty in Wales by residual income (residual income definition)

Thousand households/ *Row percentages*

Residual income (equivalised)	Residual – new thresholds			Residual - normal thresholds			Total
	All households in fuel poverty		In severe FP	All households In fuel poverty		In severe FP	house-holds
	thousands	*percent*	*percent*	thousands	*percent*	*percent*	thousands
Lowest quintile	195	*84.4*	*27.2*	216	*93.1*	*57.7*	231
Second quintile	98	*42.2*	*2.4*	155	*67.1*	*13.7*	231
Middle quintile	43	*18.8*	*0.9*	83	*35.8*	*4.5*	231
Fourth quintile	18	*7.7*	*0.4*	40	*17.2*	*1.6*	231
Highest quintile	8	*3.4*	*0.5*	16	*7.1*	*1.2*	231
Totals	**362**	***31.3***	***6.3***	**510**	***44.1***	***15.8***	**1157**

Home status and heating regimes

4.22 The final table in this section shows the frequency and severity of fuel poverty for the different household circumstances which determine whether the home is heated using 'partial' heating, 'full' heating or the 'standard' heating regime. It shows that, on the full income definition, in both countries those households who are severely under-occupying their home have the highest levels of fuel poverty. This is despite the fact that such households are assumed to only partially heat their homes. A major reason for this is that this group occupy by far the largest homes and their SAP ratings are generally average. The lowest levels of fuel poverty (11%) are enjoyed by those in full time work or full time education. These households not only have the highest incomes and require the shortest heating period, but also have homes which, on average, have the highest SAP ratings.

4.23 The basic income definition, however, changes the distribution in Wales by giving households who are at home all day but not under-occupying their home, the largest percentages for both fuel poverty and severe fuel poverty. In England, whilst the order is not changed, the percentage gap between the two categories is considerably reduced. This is due to the fact that in both countries a higher proportion of younger households receive housing benefit than older households, while severe under-occupation is heavily concentrated amongst older households. *(Table 4.14)*

Table 4.14: Fuel poverty in Wales and England by home status (full & basic incomes)

Thousand households/ *Row percentages*

Home status by country	Full income definition: All households in fuel poverty thousands	Full income definition: All households in fuel poverty *percent*	Full income definition: In severe FP *percent*	Basic income definition: All households in fuel poverty thousands	Basic income definition: All households in fuel poverty *percent*	Basic income definition: In severe FP *percent*	Total house-holds thousands
WALES							
Under-occupying home	125	*39.0*	*9.3*	127	*39.8*	*11.8*	319
At home all day	207	*36.7*	*6.7*	235	*41.9*	*12.9*	562
In full-time work/study	29	*10.6*	*1.4*	31	*11.4*	*2.6*	276
Totals for Wales	**360**	***31.0***	***6.2***	**394**	***34.0***	***10.2***	**1157**
ENGLAND							
Under-occupying home	1575	*31.5*	*6.3*	1701	*34.0*	*8.0*	5002
At home all day	2414	*23.8*	*2.6*	3235	*31.9*	*5.7*	10124
In full-time work/study	278	*6.2*	*1.4*	307	*6.8*	*1.6*	4516
Totals for England	**4274**	***21.8***	***3.3***	**5241**	***26.7***	***5.4***	**19643**

4.24 With a much higher proportion of larger households in fuel poverty under the equivalised residual income definition, households who are severely under-occupying their home no longer have the highest rates of fuel poverty. Using either the 13% or 10% thresholds with the residual income definition, the highest rates (43% and 57% respectively) are clearly to be found amongst households who are at home all day but not in severe under-occupation. Whilst those in full time work or education still have the lowest overall rates of fuel poverty, they now follow close behind those in severe under-occupation. 20% of such households need to spend more than 13% of their residual income on fuel and 31% need to spend over 10%. *(Table 4.15)*

Table 4.15: Fuel poverty in Wales by home status (Equivalised residual incomes)

Thousand households/ *Row percentages*

Home status	Residual – new thresholds: All households in fuel poverty thousands	Residual – new thresholds: All households in fuel poverty *percent*	Residual – new thresholds: In severe FP *percent*	Residual - normal thresholds: All households in fuel poverty thousands	Residual - normal thresholds: All households in fuel poverty *percent*	Residual - normal thresholds: In severe FP *percent*	Total house-holds thousands
Under-occupying home	66	*20.7*	*2.6*	105	*32.9*	*7.9*	319
At home all day	241	*42.8*	*9.8*	320	*57.0*	*23.6*	562
In full-time work/study	55	*20.0*	*3.3*	84	*30.6*	*8.8*	276
Totals	**362**	***31.3***	***6.3***	**510**	***44.1***	***15.8***	**1157**

PART 5: GEOGRAPHICAL DISTRIBULTION

Urban and rural locations

5.1 Rural and urban dwellings are classified in the 1997/98 WHCS, as in the 1996 EHCS, by the surveyors assessing the surroundings of each sample dwelling. Thus, dwellings can be classified as rural, even if located in a predominantly urban unitary authority and vice versa.

5.2 In both countries, rural housing tends to have higher levels of fuel poverty and severe fuel poverty than urban housing, but the difference is more marked in Wales. Here, 39% of rural households are fuel poor, of which some 11% of all households are in severe fuel poverty. This compares with frequencies of 29% and 5% respectively for urban areas in Wales. Under the basic income definition, the rates of fuel poverty increase slightly more in urban than in rural areas, but the proportion of households in fuel poverty still remained significantly greater in rural areas. This is in contrast to England, where, the proportion of fuel poverty in urban areas exceeds that in rural locations. *(Table 5.1)*

Table 5.1: Fuel poverty in Wales and England by location (Full & Basic incomes)

Thousand households/ *Row percentages*

Location	Full income definition			Basic income definition			Total
by country	All households in fuel poverty		In severe FP	All households in fuel poverty		In severe FP	house-holds
	thousands	*percent*	*percent*	thousands	*percent*	*percent*	thousands
WALES							
Rural location	90	*38.9*	*10.7*	92	*39.9*	*12.2*	231
Urban location	271	*29.2*	*5.0*	302	*32.6*	*9.6*	927
Totals for Wales	**360**	***31.0***	***6.2***	**394**	***34.0***	***10.2***	**1157**
ENGLAND							
Rural location	902	*23.4*	*4.7*	1005	*26.1*	*5.8*	3853
Urban location	3371	*21.3*	*2.9*	4237	*26.8*	*5.3*	15790
Totals for England	**4274**	***21.8***	***3.3***	**5241**	***26.7***	***5.4***	**19643**

5.3 Using residual incomes has comparatively little effect on the distribution of fuel poverty between rural and urban areas. It reduces the divergence slightly, particularly with respect to severe fuel poverty. However, keeping the traditional thresholds of 10% and 20% increases the numbers considerably. Over half of all rural households are now classed as fuel poor on this definition, with a fifth living in severe fuel poverty. *(Table 5.2)*

Table 5.2: Fuel poverty in Wales by location (Equivalised residual incomes)

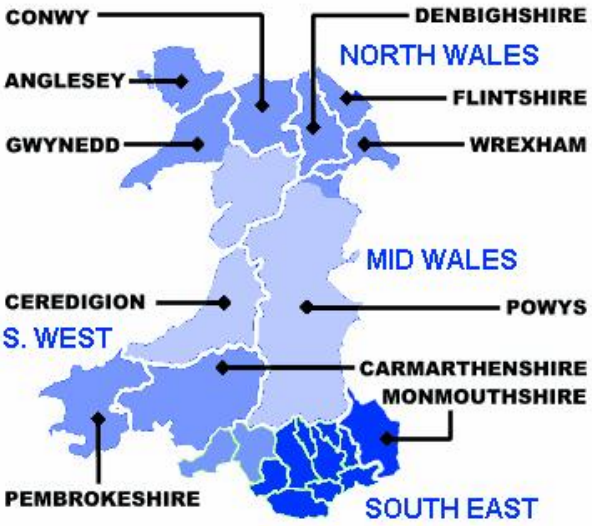
Thousand households/ *Row percentages*

Location	Residual – new thresholds			Residual - normal thresholds			Total
	All households in fuel poverty		In severe FP	All households in fuel poverty		In severe FP	house-holds
	thousands	*percent*	*percent*	thousands	*percent*	*percent*	thousands
Rural location	88	*38.0*	*8.5*	119	*51.7*	*20.1*	231
Urban location	275	*29.6*	*5.7*	391	*42.2*	*14.7*	927
Totals	**362**	***31.3***	***6.3***	**510**	***44.1***	***15.8***	**1157**

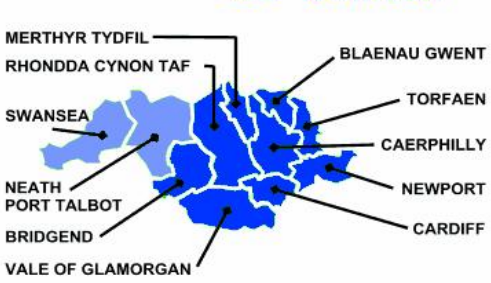
Regional areas

5.4 The above general analysis of the distribution of fuel poverty showed that homes in rural locations generally had a higher proportion of fuel poor households than urban areas. Therefore, it is not surprising that on the full and basic income definitions, the highest levels of fuel poverty are to be found in Mid Wales (39% & 40%) and South West Wales (35% & 37% respectively). Mid Wales has the smallest divergence in the numbers in fuel poverty on these two definitions, having a particularly low proportion of households in receipt of housing benefit (8%). Conversely, with 15% of households in receipt of housing benefit, South East Wales has the largest divergence. However, on both definitions, this area has the lowest proportion of fuel poor households (29% and 32%), but due to its large total population still accounts for around 44% of all households in fuel poverty in Wales. *(Table 5.3)*

Figure 5.1 Regional Areas and Unitary Authorities in Wales



Note: North Wales includes the northern tip of Powys and Mid-Wales thesouthern part of Gwynedd



Authorities in South West and South East Wales not named on main map

Table 5.3: Fuel Poverty in Wales by Regional areas (full and basic incomes)

Thousands/ *Row percentages*

Regional area	Full income definition			Basic income definition			House-holds with HB	Total house-holds
	All households in fuel poverty		In severe FP	All households in fuel poverty		In severe FP		
	thousand	*percent*	*percent*	thousand	*percent*	*Percent*	*percent*	thous.
Mid Wales	36	*38.5*	*11.1*	37	*39.8*	*13.5*	*8.0*	93
South West Wales	91	*34.9*	*7.0*	97	*37.3*	*10.7*	*13.1*	261
North Wales	76	*30.1*	*6.5*	83	*32.9*	*9.6*	*12.8*	253
South East Wales	157	*28.6*	*4.8*	176	*32.1*	*9.6*	*14.6*	550
Total for Wales	**360**	***31.0***	***6.2***	**394**	***34.0***	***10.2***	***13.3***	**1157**

5.5 The regional distribution of fuel poverty is not materially changed by the use of the residual income definition. Under both the new and traditional thresholds, the rank order of the regions remains the same. However, there is a slight tightening in the range between Mid Wales and South East Wales, particularly between the proportions in severe fuel poverty. The penultimate column in Table 5.4 gives the total percentage of households in each region that are classed as vulnerable and shows comparatively little variation across the regions. *(Table 5.4)*

Table 5.4: Fuel poverty in Wales by Regional Areas (equivalised residual incomes)

Thousands/ *Row percentages*

Regional area	Residual – new thresholds			Residual - normal thresholds			Vulner-able Hholds	Total house-holds
	All households in fuel poverty		In severe FP	All households in fuel poverty		In severe FP		
	thousand	*percent*	*percent*	thousand	*percent*	*Percent*	*percent*	thous.
Mid Wales	35	*37.1*	*9.2*	47	*50.3*	*20.0*	*70.2*	93
South West Wales	88	*33.8*	*6.3*	123	*47.2*	*16.6*	*72.6*	261
North Wales	80	*31.5*	*6.0*	113	*44.6*	*15.7*	*69.3*	253
South East Wales	160	*29.0*	*5.9*	227	*41.3*	*14.7*	*70.1*	550
Total	**362**	***31.3***	***6.3***	**510**	***44.1***	***15.8***	***70.5***	**1157**

5.6 Table 5.5 suggests that the high proportion of households in fuel poverty in Mid Wales is not primarily attributable to low incomes, since these are generally higher than the national average. The main problems appear to be poor energy efficiency and the particularly large number of homes lacking a gas supply (58%) and thus liable to have high fuel prices. However, under-occupation is also a major problem, as is, to a lesser extent, the lack of small homes. Low incomes appear more of a problem in South West Wales where SAP ratings are average, although

this region also has a high proportion of homes with no mains gas, significant under-occupation and the lowest proportion of small homes (17%).

Table 5.5: Causal Factors in Fuel Poverty in Wales by Regional Areas

Pounds/Row percentages/*SAP/p-kWh*

New TEC areas	a. Full Income		b. Basic inc	c. Residual	d. Energy SAP ratings[1]		e. With no gas supply	f. Under occupy	g. Small homes	Total house holds [1]
	Mean	<£9100	Mean	Mean	Mean	*<20*		>1.5P Mean	<69m^2	
	£	*percent*	£	£	SAP	*percent*	*percent*	*percent*	*percent*	thous[1]
Mid Wales	14,994	*34.5*	14,820	11,601	36.3	*21.2*	*57.6*	*69.6*	*18.0*	93
S. W. Wales	14,155	*39.0*	13,890	10,710	41.3	*13.1*	*26.4*	*63.0*	*16.7*	261
North Wales	14,700	*36.1*	14,427	10,710	39.4	*16.1*	*29.8*	*60.6*	*21.4*	253
S. E. Wales	14,569	*37.4*	14,226	10,913	42.4	*11.2*	*7.9*	*54.1*	*21.4*	550
Total Wales	**14,539**	***37.3***	**14,242**	**10,957**	**41.0**	***13.5***	***20.9***	***58.8***	***20.1***	**1157**

5.7 The better position of North Wales can be attributed to an above average distribution of incomes and provision of small homes, with only marginally below average SAP ratings and above average under-occupancy. However, a large proportion of the stock in North Wales lacks a gas supply (30%). In contrast, few homes (8%) lack mains gas in South East Wales, where incomes are average and problems of energy efficiency, under-occupation and lack of small homes are all better than average. *(Table 5.5)*

Unitary authorities

5.8 As for the regions, Table 5.6 ranks the unitary authorities in Wales by the proportion of all their households in fuel poverty on the 'full' income definition. The table also shows the number of fuel poor and proportion of households in severe fuel poverty on both the 'full' and 'basic' income definitions, as well as the proportion of all households in receipt of housing benefit. However, due to the relatively small sample sizes the results need to be treated with some caution. (The Training and Enterprise Council or TEC region is given after the name of each authority, the southern half of Gwynedd being in Mid Wales and the northern tip of Powys falling in North Wales).

5.9 On the full income definition, the proportion of households in fuel poverty ranges from 43% in Carmarthenshire to 25% in the Vale of Glamorgan, while the proportion of households in severe fuel poverty ranges from 12% to 4% in the same authorities. Carmarthenshire and the Vale of Glamorgan also take the highest and lowest positions on the 'basic' income definition, with respectively 45% and 28% of all households classed as fuel poor. However, on this definition Blaenau Gwent has an equally high proportion of households in severe fuel poverty (14%), while Wrexham has the lowest proportion (8%).

Table 5.6: Fuel Poverty in Wales by Unitary Authority (full and basic incomes)

Thousands/ *Row percentages*

Regional area	Full income definition			Basic income definition				Total households
	All households in fuel poverty		In severe FP	All households in fuel poverty		In severe FP	Households with HB	
	thous	*percent*	*percent*	Thousand	*percent*	*percent*	*percent*	thous
Carmarthenshire SW	29	*43.2*	*11.7*	31	*45.0*	*14.3*	*11.1*	68
Powys M (N)	21	*38.9*	*11.5*	22	*40.2*	*13.7*	*8.1*	54
Ceredigion M	10	*38.5*	*11.4*	10	*40.2*	*13.7*	*7.5*	26
Merthyr Tydfil SE	8	*38.1*	*6.5*	9	*40.8*	*13.1*	*20.1*	21
Gwynedd N & M	17	*37.9*	*9.5*	18	*40.0*	*13.3*	*14.1*	45
Pembrokeshire SW	16	*35.3*	*7.6*	17	*36.9*	*11.0*	*12.4*	46
Neath Port Talbot SW	20	*34.6*	*5.6*	21	*37.4*	*9.6*	*14.6*	57
Caerphilly SE	21	*34.5*	*5.2*	24	*39.1*	*11.8*	*18.1*	62
Blaenau Gwent SE	10	*34.4*	*6.9*	11	*39.7*	*14.3*	*21.8*	28
Isle of Anglesey N	9	*33.9*	*8.2*	10	*35.4*	*11.1*	*11.1*	28
Rhondda C.T. SE	28	*30.2*	*5.2*	31	*33.2*	*9.1*	*13.1*	92
Flintshire N	17	*29.1*	*7.4*	18	*31.4*	*9.8*	*11.5*	58
Denbighshire N	11	*28.8*	*5.3*	12	*31.0*	*7.9*	*9.5*	38
Swansea SW	26	*28.7*	*4.0*	28	*31.6*	*8.6*	*13.9*	89
Conwy N	13	*28.4*	*6.1*	14	*31.0*	*9.2*	*11.3*	47
Newport SE	16	*28.3*	*3.9*	18	*32.5*	*9.1*	*16.3*	55
Bridgend SE	14	*27.3*	*5.5*	15	*28.6*	*8.1*	*9.9*	53
Monmouthshire SE	9	*27.2*	*6.5*	10	*29.3*	*9.1*	*9.5*	33
Wrexham N	14	*26.5*	*3.9*	16	*31.1*	*7.8*	*17.0*	52
Torfaen SE	10	*26.5*	*4.1*	11	*30.5*	*8.5*	*17.5*	37
Cardiff SE	30	*24.8*	*3.8*	35	*28.4*	*8.6*	*14.0*	121
V. of Glamorgan SE	12	*24.6*	*3.8*	13	*28.0*	*8.9*	*12.2*	48
Total for Wales	**360**	***31.0***	***6.2***	**394**	***34.0***	***10.2***	***13.3***	**1,157**

5.10 After Carmarthenshire, there are four authorities (Powys, Ceredigion, Merthyr Tydfil and Gwynedd) with 38 to 39% of households in fuel poverty on the 'full' income definition and 40% or over in fuel poverty on the 'basic' income definition. On both definitions, Cardiff has the lowest proportion of fuel poor after the Vale of Glamorgan, but, due to its large population, the greatest number of fuel poor households (around 30,000) of any authority. *(Table 5.6)*

5.11 The residual income definition has a greater effect on the ranking of some unitary authorities than others, as shown in Table 4.5. Carmarthenshire retains the highest level of fuel poverty and the Vale of Glamorgan the lowest, the difference in rates between the two being only marginally reduced. Powys, Gwynedd and Merthyr Tydfil also remain in the 'top' five. However, Ceredigion improves its position from 3rd to 7th place, while Caerphilly and the Isle of Anglesey worsen from 8th to 4th and 10th to 6th place respectively.

5.12 In the bottom half of the list, Denbighshire and Bridgend both improve by four places, the latter now taking the penultimate position next to the Vale of Glamorgan. Cardiff now has the third best position. However, the greatest relative increase in fuel poverty occurs in Wrexham, this moving from the fourth best position to 11th place under the residual income definition. The rank order of all other authorities changes by 3 places or less. *(Table 5.7)*

Table 5.7: Fuel Poverty in Wales by unitary authority (equivalised residual incomes)

Thousand households/ *Row percentages*

Regional area	Residual – new thresholds			Residual - normal thresholds			Vulner-able Hholds	Total house-holds
	All households in fuel poverty		In severe FP	All households in fuel poverty		In severe FP		
	Thousands	*percent*	*percent*	Thousands	*percent*	*percent*	*percent*	thous.
Carmarthenshire SW	28	*40.9*	*8.2*	37	*54.7*	*21.5*	*73.4*	68
Powys M (N)	20	*38.1*	*9.2*	28	*52.7*	*20.2*	*70.9*	54
Ceredigion M	9	*34.7*	*10.0*	12	*45.5*	*19.8*	*69.7*	26
Merthyr Tydfil SE	8	*36.9*	*7.3*	11	*50.6*	*20.9*	*78.2*	21
Gwynedd N & M	17	*38.1*	*8.2*	23	*50.8*	*20.4*	*68.1*	45
Pembrokeshire SW	15	*32.8*	*7.6*	21	*44.8*	*17.2*	*67.4*	46
Neath Port Talbot SW	18	*32.1*	*5.6*	26	*45.4*	*14.8*	*75.5*	57
Caerphilly SE	23	*37.0*	*7.1*	31	*50.3*	*16.9*	*76.3*	62
Blaenau Gwent SE	9	*34.1*	*4.8*	14	*49.7*	*14.8*	*79.9*	28
Isle of Anglesey N	10	*35.5*	*8.5*	13	*47.8*	*19.7*	*65.9*	28
Rhondda C.T. SE	27	*29.2*	*7.1*	39	*41.9*	*15.4*	*66.8*	92
Flintshire N	17	*28.9*	*5.4*	24	*42.1*	*14.0*	*66.9*	58
Denbighshire N	10	*27.8*	*5.1*	15	*39.7*	*13.3*	*68.9*	38
Swansea SW	27	*29.9*	*4.5*	39	*43.8*	*13.5*	*73.0*	89
Conwy N	14	*30.3*	*5.6*	20	*42.1*	*15.8*	*75.2*	47
Newport SE	15	*27.6*	*5.8*	22	*39.6*	*13.4*	*73.1*	55
Bridgend SE	14	*26.6*	*5.5*	20	*37.0*	*12.5*	*68.1*	53
Monmouthshire SE	9	*27.7*	*6.8*	14	*42.3*	*13.9*	*66.6*	33
Wrexham N	17	*31.8*	*4.7*	25	*47.5*	*14.4*	*69.4*	52
Torfaen SE	11	*28.6*	*2.7*	15	*41.3*	*11.5*	*69.2*	37
Cardiff SE	33	*26.9*	*5.8*	46	*37.5*	*15.5*	*66.4*	121
V. of Glamorgan SE	11	*23.3*	*4.9*	17	*35.2*	*12.1*	*70.7*	48
Total for Wales	**362**	***31.3***	***6.3***	**510**	***44.1***	***15.8***	***70.5***	***1,157***

5.13 As shown in Table 5.8, the particularly high position of Carmarthenshire, on all definitions, can be attributed to a combination of generally lower than average incomes and SAP ratings, a high frequency of homes without gas, a high incidence of under-occupation and a particularly low proportion of small properties. Although with more small homes, Gwynedd exhibits similar causal factors to Carmarthenshire.

Powys and Ceredigion record average or higher than average incomes, but here SAP ratings are generally low. Over 20% of homes have SAP ratings under 20. The number of homes lacking a gas supply and/or under-occupied is also particularly high. In contrast, the main cause of high fuel poverty in Merthyr Tydfil appears to be very low incomes. SAP ratings are average and very few dwellings lack gas. The level of under-occupation and the lack of small homes is also better than average.

5.14 At the foot of the Table, the good positions of Cardiff and the Vale of Glamorgan can be attributed to generally higher than average incomes, better than average energy efficiency and a high proportion of homes with a gas supply, particularly in the case of Cardiff where only 3% of homes lack a supply. Under-occupation is also lower than the national average, while the proportion of small homes is greater than average in these authorities. Those authorities whose position is significantly improved under the residual income definition, Ceredigion, Denbighshire and Bridgend, have higher than average residual incomes. Conversely, those authorities whose position gets significantly worse, Caerphilly, Torfaen and Wrexham, have generally lower than average residual incomes. *(Table 5.8)*

Table 5.8: Causal factors in fuel poverty in Wales by unitary authorities

Pounds*/Row percentages/*SAP/p-kWh

Unitary authorities	a. Full income		b. Basic inc.	c. Resi-dual	d. Energy SAP ratings[1]		e. With no gas supply	f. Under-occupy	g. Small homes	Total households[1]
	Mean	<£9100	Mean	Mean	Mean	< 20		>1.5 PM	< 69 m^2	
	£	*percent*	£	£	SAP	*p'cent*	*percent*	*percent*	*percent*	thous[1]
Carmarthenshire	13836	*39.5*	13628	10657	38.6	*16.1*	*46.2*	*66.9*	*14.4*	68
Powys	15665	*33.4*	15499	11625	36.5	*20.7*	*51.4*	*69.4*	*15.5*	54
Ceredigion	14436	*36.0*	14240	11954	37.1	*20.3*	*73.1*	*71.4*	*20.6*	26
Merthyr Tydfil	12254	*46.6*	11865	9100	41.1	*9.7*	*3.7*	*49.3*	*22.1*	21
Gwynedd	13514	*38.3*	13230	10577	36.4	*19.8*	*48.1*	*65.5*	*17.6*	45
Pembrokeshire	14792	*37.7*	14520	11700	38.3	*17.0*	*43.2*	*66.0*	*20.4*	46
Neath Prt Talbot	13738	*41.6*	13437	10367	41.7	*11.7*	*16.2*	*58.2*	*16.1*	57
Caerphilly	13410	*43.1*	12973	9588	40.5	*9.8*	*7.1*	*47.8*	*23.2*	62
Blaenau Gwent	11845	*49.3*	11329	8974	41.8	*8.6*	*7.8*	*46.0*	*28.9*	28
Isle of Anglesey	15970	*32.3*	15750	11364	37.5	*18.8*	*56.3*	*63.8*	*14.5*	28
Rhondda C.T.	14173	*39.2*	13900	10819	41.6	*12.8*	*8.4*	*54.4*	*18.8*	92
Flintshire	15408	*36.5*	15175	11622	41.0	*17.5*	*25.0*	*62.4*	*23.3*	58
Denbighshire	14813	*35.5*	14575	11616	38.6	*15.2*	*30.4*	*64.9*	*21.2*	38
Swansea	14336	*37.8*	14052	10455	44.5	*9.8*	*9.1*	*61.5*	*17.0*	89
Conwy	14192	*36.0*	13926	11325	38.9	*16.1*	*22.3*	*60.1*	*23.6*	47
Newport	13957	*39.2*	13558	10662	44.6	*8.5*	*6.8*	*54.3*	*20.2*	55
Bridgend	15342	*32.2*	15141	11899	42.0	*12.9*	*10.2*	*58.9*	*17.1*	53
Monmouthshire	16802	*30.7*	16555	12133	41.0	*12.5*	*26.9*	*65.2*	*14.7*	33
Wrexham	14323	*36.0*	13985	10058	41.1	*12.8*	*18.0*	*51.7*	*25.0*	52
Torfaen	14257	*37.5*	13868	10673	43.3	*8.8*	*3.9*	*53.0*	*22.0*	37
Cardiff	15325	*34.1*	14971	11377	43.1	*12.7*	*2.9*	*54.3*	*24.4*	121
V. of Glamorgan	16070	*32.4*	15728	12099	43.7	*10.6*	*10.7*	*55.8*	*22.5*	48
Wales 1997/98	**14,539**	***37.3***	**14,242**	**10,957**	**41.0**	***13.5***	***20.9***	***58.8***	***20.1***	**14,539**

5.15 Overall, it is clear that the high or relatively low levels of fuel poverty, on each of the three definitions, in the different unitary authorities in Wales frequently result from different circumstances and from different combinations of the main causal factors - low incomes, poor energy efficiency, high fuel prices and under-occupation - found in these authorities.

PART 6: CONCLUSIONS

Extent of fuel poverty in Wales

6.1 With around 360,000 or 31% of all households in fuel poverty on the 'full income' definition, including 72,000 or some 6% in severe fuel poverty, Wales had significantly higher levels of fuel poverty in 1997/98 than England. However, fuel poverty in Wales was comparable with the proportion in several of the English regions in 1996, particularly Merseyside and the North East.

6.2 The high incidence of fuel poverty in Wales at this time can be attributed to a combination of low incomes, poor energy efficiency, high fuel prices (particularly for electricity), the country's relatively high levels of under-occupation and a dearth of small homes. However, the divergence with England is less when fuel poverty is measured on the 'basic' income definition. This is because, with its smaller rented sector, Wales had a significantly lower proportion of households in receipt of housing benefit.

6.3 The use of an equivalised income definition of fuel poverty increases the number of households in Wales classed as fuel poor to around 510,000 or 44%, with 82,000 or 16% living in severe fuel poverty. However, changing the thresholds to 13% and 31.5% of residual income produces similar totals (362,000 and 73,000 respectively) to 10% and 20% of full income.

The housing and households affected

6.4 In many respects, under the full and basic income definitions, the distribution of fuel poverty in Wales in 1997/98 was similar to that of England in 1996. In both countries, the owner occupied sector had the lowest proportion of fuel poverty, but the greatest numbers of fuel poor. Fuel poverty was lowest in post 1964 housing and highest in end-terraced housing. It was also highest in homes lacking central heating, without mains gas heating and those in the worst physical condition.

6.5 In Wales, as in England, over half of households with the oldest occupants were in fuel poverty. High rates were also found amongst single person households and those severely under-occupying their home. In both countries, fuel poverty and, particularly severe fuel poverty, was heavily concentrated amongst those on the lowest incomes.

6.6 That said, due to the factors listed in paragraph 6.2 above, fuel poverty was more widely distributed in Wales than in England. Compared to England, significantly higher frequencies were found in the socially rented sectors, in post-war housing, in detached and in larger sized homes. Similarly, levels were higher in Wales than in England in homes with central heating, with mains gas heating and of average energy efficiency and condition.

6.7 Correspondingly, fuel poverty in Wales was more widely distributed among the general population than in England, with significantly higher levels occurring amongst lone parent families and households with dependent children. Similarly, frequencies of fuel poverty in Wales were higher amongst middle aged and larger households and those approaching average or on average national incomes.

Effects of definition

6.8 Equivalisation, by taking account of household size and composition, significantly increases these tendencies. It deflates fuel poverty in single households and inflates it in larger family households. Consequently, under the equivalised residual income definition using the new (13% of income) threshold, households with dependent children (particularly lone parents), younger households and those renting from private landlords recorded the greatest proportion of fuel poverty. In addition, the divergence in the rates between the worst and best categories was often, but not always, reduced.

6.9 By excluding housing costs and thereby limiting income to only that available to be spent on fuel, the residual income definition also significantly strengthens the correlation between fuel poverty and low income. Under the equivalised residual income definition, the distribution of fuel poverty is much closer to that of general poverty or child poverty than is the case with the unequivalised full and basic income definitions of fuel poverty.

Geographical distribution

6.10 Under all definitions, fuel poverty in Wales is significantly higher in rural areas than in urban areas. Regionally, the highest proportions of households in fuel poverty and severe fuel poverty were to be found in Mid Wales and the lowest proportions in South East Wales. However, with its large population, the latter region still held the largest share (44%) of all fuel poor households in Wales.

6.11 On the full and basic income definitions, Cardiff had the largest number of fuel poor households of any unitary authority, but the lowest proportion next to the Vale of Glamorgan. On both definitions, Carmarthenshire, Powys, Ceredigion, Merthyr Tydfil and Gwynedd had the highest proportions of households in fuel poverty and severe fuel poverty. Using residual income changed the rank order of some authorities more than others, but left Carmarthenshire and the Vale of Glamorgan at the top and bottom of the list. Under each definition, the different ranking of the authorities appears to stem from a variety of causes and combinations of causes.

Trends since 1997/98

6.12 In 1997/98, the prevalence of fuel poverty in Wales was high, but it is likely that it has fallen substantially since that date. In England, the 2001 EHCS estimated that the number of households in fuel poverty had fallen by as much as 60% since 1996

on the 'full' income definition, from 4.3 to 1.7 million [9]. As this fall resulted primarily from reductions in fuel prices after 1996 and higher incomes in 2001, it is likely that by 2001 fuel poverty in Wales had also fallen by a broadly comparable proportion. However, since 2001, fuel prices have begun to rise in real terms, with the consequence that in both countries this trend is now likely to have reversed.

6.13 While fuel poverty estimates may be lower in absolute terms, it is likely that the current distribution of fuel poverty in the Welsh housing stock, amongst the household population and geographically remains similar to the situation in 1997/98 – as described in this report.

[9] Due to significant changes in the 2001 EHCS methodology, however, the 1996 and 2001 estimates may not be strictly comparable.

ANNEX A: THE 1997/98 WHCS SAP MODEL

INTRODUCTION

The Standard Assessment Procedure for Energy Rating of Dwellings or SAP was first published in 1993, and has been revised on several occasions, the latest version being SAP 2001. The 1997/98 WHCS SAP model is based on the 1998 version and worksheet 9.60 (BRE/SO/WO/DETR, 1998). Although slightly less comprehensive than the latest version, particular in the extent to which it also calculates carbon emissions, this was the version of SAP used for the analysis of the 1996 EHCS and is the one most appropriate to the 1997/98 WHCS.

This Annex describes the stages undertaken to give each individual sample dwelling in the 1997/98 WHCS physical survey a SAP rating. For each of the 100 plus stages in the SAP calculation, it lists the specific information required (with stage numbers from the SAP Worksheet in brackets).

Where data needs to be imputed from the 1996 EHCS, the paper lists the relevant EHCS variables (in italics) and the common EHCS and WHCS variables used in the imputing process, with references to the appropriate sections in the English or Welsh physical surveys (EPS or WPS) and interview surveys (EIS or WIS). It then describes the imputing procedure used and the main assumptions underlying this methodology.

After so describing any imputed variables, each section (or sub-section) lists the WHCS variables used in the 11 main stages of the SAP calculation. It then describes the methodology used in determining the required information from the WHCS and any imputed variables. The SAP calculations required for that stage are then given. Finally, for each section, the main assumptions underlying the particular methodology are provided. Where possible, these assumptions have been tested using the more comprehensive EHCS data-set and/or other information.

The Annex has two additional sections as follows:-

1. Annex A1, *Imputing SAP related Floors Areas for the WHCS Sample,* describes the methodology used for imputing floor areas and other variables from the 1996 EHCS.
2. Annex A2, *Calculated U-Values for Walls, Roofs and Floors* lists the U-values used in the WHCS SAP model that are not provided by the SAP Tables.

1. OVERALL DWELLING DIMENSIONS

a) Total floor area

SAP (1-5): requires the internal floor area (as specified by the SAP procedure) for each sample dwelling in the 1997/98 WHCS.

Variables for imputing floor areas: The SAP related floor area for each dwelling was imputed from the 1996 EHCS using the following EHCS and WHCS variables:-

- *SAP related floor area (from EHCS energy files)*
- Tenure (E derived & WIS derived)

- Dwelling type (E derived & WPS.2.3 & WIS.B)
- Number of floors in dwelling (EPS 8 & 13 & W derived, as at SAP 11/12 below)
- Whether attic and/or basement present (E derived & WPS 3.26)
- Date of construction (EPS 4 & WPS 2.5)
- Location – urban/rural (E derived & WPS 7)
- Number of habitable rooms (E derived & WPS 3.1A)
- Number of bedrooms (E derived & WIS 3.1A)

Methodology: Using the EHCS sample, regression analysis was used to determine from a longer list of potentially relevant variables, the above common variables as the main EHCS/WHCS variables influencing the floor area in different tenures. With these variables, a comprehensive typology of dwelling 'types', where similar floor areas might be expected, was constructed for each tenure, for both the EHCS and WHCS samples. For the EHCS sample, the standard deviation for the floor areas for each dwelling category was checked to ensure that these were tightly distributed. Where necessary, the typologies were then revised to achieve tighter groupings. Finally, the mean EHCS SAP related floor area for each dwelling category was assigned to the same dwelling categories in the WHCS. (See Annex B for details of this methodology).

SAP calculation:- The total floor area (in m2) was given directly by the imputed variable. (SAP stages 1 to 4 for the area and average room height of each floor were not required).

(SAP5) Total floor Area = imputed total floor area.

Assumptions: The above methodology was based on the following main assumption, namely that:-

- Dwellings in Wales and England of the same tenure, type, floor number and types, age, location and with the same number of bedrooms and/or habitable rooms have similar SAP related floor areas, these variables being shown to be the main influences on floor areas in the England housing stock.

b) Total dwelling volume

SAP (6): requires the average room height to determine the total dwelling volume for each sample dwelling in the WHCS.

Variables for imputing room heights: The SAP related floor area for each dwelling was imputed from the EHCS using the following EHCS and WHCS variables:-

- *Room heights (EPS 5)*
- *Level of room (EPS 5)*
- Dwelling type (E derived & WPS.2.3 & WIS.B)
- Number of floors in dwelling (EPS 8 & 13 & W derived, as at SAP 11/12 below)
- Whether attic and/or basement present (E derived & WPS 3.26)
- Date of construction (EPS 4 & WPS 2.5)
- Location – urban/rural (E derived & WPS 7)
- Number of habitable rooms (E derived & WPS 3.1A)

Methodology: Using the EHCS sample, the average heights for rooms at each level were determined and from this the overall average room height calculated for each dwelling. Regression analysis was then used to determine from a longer list of potentially relevant variables, the above common variables as the main EHCS/WHCS variables influencing the average floor height in a dwelling. With these variables, a comprehensive typology of dwelling 'types', where similar room heights might be expected, was constructed for both the EHCS and WHCS samples. For the EHCS sample, the standard deviation for the room heights for each dwelling category was checked to ensure that these were tightly distributed. Finally, the mean room height for each dwelling category was then assigned to the same dwelling categories in the WHCS.

SAP calculation: The dwelling volume (in m^3) was then calculated as follows:-
(SAP6) Dwelling volume = SAP5 x imputed average room height.

Assumptions: The methodology was based on the following main assumption, that:-

- Dwellings in Wales and England of the same type, floors number and type, age, location and with the same number of habitable rooms have similar average room heights, these variables being shown to be the main influences on room heights in England.

2. VENTILATION RATE

a) Infiltration due to chimneys, fans and flues

SAP (7-10): requires information on the number of chimneys, open flues, fans and passive vents.

Variables for SAP calculation: The number of chimneys, open flues and fans in each dwelling was calculated using the following WHCS variables:-

- The fuel used for fixed other heating (WPS 3.24)
- Whether fixed other heaters in each room (WPS.3.7)
- Number of chimney stacks (WPS 6.1)
- The fuel used for central heating (WPS 3.24)
- Combination or other higher efficiency boiler (WPS derived as at s. 7a below)
- Extractor fan in kitchen (WPS 3.18)
- Extractor fan in bathroom (WPS 3.19)

Methodology: Fixed other heaters recorded in each of the sample rooms, except the bathroom, were assumed to be of the type subsequently coded in the heating section. Those fuelled by gas, LPG, solid fuel or fuel oil were assumed to require a chimney. Thus, the number of chimney flues was calculated as the number of rooms with fixed heating, subject to chimney stacks also being recorded in the external section.

Central heating systems fuelled by gas, LPG, solid fuel or fuel oil were assumed to have an open flue, unless there were indicators suggesting they could be a combination or higher efficiency boiler. In this case they were assumed to have balanced flues, and therefore not counted in this part of the SAP calculation.

The number of fans was determined directly from the questions on extractor fans in the kitchen and/or bathroom. It was assumed that none of the WHCS sample dwellings had passive stacks, such ventilation being rare prior to 1997/98.

SAP calculations:- The ventilation rates (in m^3 per hour) and infiltration (in air changes per hour) for chimneys, flues and fans were then calculated as follows:-

(SAP7) Number of chimneys **=** Number x 40.
(SAP8) Number of flues = Number x 20.
(SAP9) Number of fans and passive vents = Number x 10.
(SAP10) Infiltration from chimneys, fans & flues = (SAP7+SAP8+SAP9)/SAP6.

Assumptions: The methodology was based on the following assumptions, that:-

- The fixed other heating in the interior section was the same as that recorded in the heating section, even where found in more than one room.
- That there was a strong correlation between the type of boiler and the type of flue as in the EHCS.
- That there were no passive stack systems in the 1997/96 WHCS sample.

b) Infiltration due to stack effects
SAP (11-12): requires the number of storeys in the dwelling.

Variables used: The number of storeys in each dwelling (not the block) was calculated using the following WHCS variables:-

- Levels of 5 specified rooms (PS.3.1B)
- Presence of stairs in the dwelling (PS.3.9)
- Type of dwelling: flat, bungalow or house (PS.2.3 & IS.B)
- Presence of attics and/or basements (PS.3.26)

Methodology: The highest and lowest level of the five specified rooms selected for inspection was determined to provide a variable indicating the number of floors. However, as these five rooms frequently represent only a sample of all rooms, a second derived variable estimating the minimum number of floors in the dwelling was constructed using the WHCS data on the type of dwelling (flat, bungalow or house), the presence of stairs in the dwelling, and the presence of a basement, attic or both. The two variables were then compared and the one generating the largest number was taken as determining the most likely number of storeys in the dwelling.

SAP calculations:- The infiltration rates (in air changes per hour) were then calculated as follows:-

(SAP11) Number of storeys = derived number of storeys.
(SAP12) Additional infiltration = (SAP11 – 1) x 0.1.

Assumptions: The methodology was based on the following assumption, that:-

- In most sample dwellings, either rooms at both the highest and lowest levels were inspected or the type of house and the presence of an attic and/or basement correctly indicated the number of storeys, the vast majority of dwelling being under 3 storeys.

c) Infiltration due to construction and adequacy of draught proofing
SAP (13-19): requires type of wall construction, if sealed or unsealed suspended floors, if draught lobby, and the percentage of doors and windows draught proofed.

Variables for SAP calculation: The type of wall construction, if sealed or unsealed suspended floors, if draught lobby, and % of window draught proofed was calculated using the following WHCS variables:-

- Area of wall structure of nine types in the front and back views (WPS 6.5)
- Presence of solid floors (WPS 3.3)
- Whether the floors had faults (WPS 3.3).
- Level of recorded rooms (WPS 3.1B)
- Number of porches in the front and back views (WPS.6.7)
- Number of windows of each of seven types in the front and back views (WPS.6.8)
- Whether these windows had faults (WPS 6.8).
- Number of external doors of each of four types in the front and back views (WPS 6.9)
- Whether these doors had faults (WPS 6.9).
- Whether doors/windows draught stripped (WIS 1.12)

Methodology: The WHCS data on the area of wall structures of different types was used to determine if the dwelling was predominantly steel or timber frame, or similar pre-fabricated construction or built of masonry or similar in-situ construction such as concrete. The presence of suspended floors (ie, not solid) was determined for rooms at ground or basement level and assumed to be unsealed unless constructed after 1964 and having no faults.

The total number of fully enclosed porches was determined directly from the WPS external questions. Doors and windows were taken as 100% or 50% or less draught proofed (depending on the number and type) where, respectively, full or partial draught proofing was reported by householders. However, elsewhere, UPVC doors and all double glazed windows were assumed to be draught proofed, unless they had faults.

SAP calculations:- Further infiltration rates (in air changes per hour) were then calculated as follows:-

(SAP13) Structural infiltration = 0.25 for steel or timber frame etc or 0.35 for masonry construction etc.
(SAP14) If suspended floors = 0.2 (sealed) or 0.1 (sealed).
(SAP15) If no draught lobby = 0.05.
(SAP16) Percentage of windows & doors draught-stripped = Derived as above.
(SAP17) Window infiltration = 0.25 – (0.2 x SAP16/100).
(SAP18) Infiltration rate = SAP10+SAP12+SAP13+SAP14+SAP15+SAP17.
(SAP19) As no pressurisation test SAP19 = SAP18.

Assumptions: The methodology was based on the following assumptions, that:-

- Precast concrete, metal sheet and the few other wall structures had similar infiltration rates to timber and steel frame, while insitu concrete was akin to cavity and solid masonry construction in this respect.
- Suspended floors are generally unsealed unless constructed after 1964 and having no faults.
- Where not reported draught proof, UPVC doors and all double glazed windows are draught proof, except where they have faults, possible indicating an older type.

d) Ventilation rate calculations

SAP (20-25): in addition to the data above, this main section requires the number of sheltered sides to each dwelling and whether the dwelling has mechanical or natural ventilation.

Variables for SAP calculation: The number of sheltered sides to each dwelling was calculated using the following WHCS variables:-

- The number of sides fully or partially attached (WPS derived from 5.2)

Methodology: The number of sides of each dwelling fully and partially attached was determined and the results rounded up to give the total equivalent number of whole sides attached. As instructed in the SAP worksheet where the location is unknown, two sides of each dwelling were assumed to be sheltered, except where the equivalent number of attachments exceeded two sides.

SAP calculations:- The effective air change rate was then calculated as follows:-

(SAP20) Number of sides on which sheltered = 2 or 3 (as determined above)
(SAP21) Shelter factor = 1 – (0.075 x SAP20).
(SAP22) If mechanical ventilation with heat recovery = 0 (assuming none)
(SAP23) If natural ventilation, air change rate = SAP19 x SAP21.
(SAP24) If SAP23 >= 1, then SAP24 = SAP23.
otherwise SAP24 = 0.5 + (SAP23 ^{2} x 0.5)
(SAP25) Effective air change rate = SAP24 (assuming not SAP22).

Assumption: The methodology for this stage was based on the following assumption, namely that:-

- All dwelling were naturally ventilated, very few existing dwellings built before 1997/98 having whole-dwelling mechanical ventilation systems.

3. HEAT LOSSES AND HEAT LOSS PARAMETERS

a) Doors

SAP (26): required the area and U-values for the external doors in each dwelling.

Variables for SAP calculation: The area of external doors in each dwelling having different u-values was calculated using the following WHCS variables:-

- Number of external doors of each of four types in the front and back views (WPS 6.9)
- Whether these doors had faults (WPS 6.9).

Methodology: For each sample address, the numbers of doors of each type (wood, metal, UPVC or other) that were either sound or had faults was determined. Typical external door sizes were assumed and the total door area calculated for each type and condition. Using SAP Table 6b *Indicative U-values (W/m^2K) for windows, doors and roof-lights*, appropriate U-values, from a total of 8 different values, were then assigned to each door area, depending on the door type and condition.

SAP calculations:- The heat loss from doors for each door type was then calculated as follows:-

(SAP25) Heat loss from doors **=** Area of door/s (m^2) x U-value (W/m^2K).

Assumptions: The above methodology included the following assumptions, that:-

- An average external door has an area of 1.8 square metres.
- Doors with faults have a slightly higher/worse average U-value than those of the same type that have no faults.

b) Windows

SAP (27-28): required the area and U-values for the windows in each dwelling.

Variables for fenestration ratio: The fenestration ratio i.e. the area of window and door openings as a proportion of the total elevational area, for each dwelling was imputed from the EHCS using the following EHCS and WHCS variables:-

- *The fenestration ratio (EPS.16)*
- Dwelling type (E derived & WPS.2.3 & WIS.B)
- Dwelling age (EPS 4 & WPS 2.5)
- Location (E derived & WPS 7)
- Number of rooms (E derived & WPS 3.1A)

Methodology: Using the EHCS sample, regression analysis was used to determine from a longer list of potentially relevant variables the above common variables as the main EHCS/WHCS variables influencing the fenestration ratio. With these variables, a comprehensive typology of dwelling 'types', where similar fenestration areas might be expected, was constructed for both the EHCS and WHCS samples. For the EHCS sample, the standard deviation for the fenestration ratios for each dwelling category was checked to ensure that these were tightly distributed. The mean EHCS fenestration ratio for each dwelling category was then assigned to the same dwelling categories in the WHCS.

Assumptions: The above methodology was based on the following main assumption, namely that:-

- Dwellings in Wales and England of the same type, age, location and with the same number of habitable rooms have similar fenestration ratios, these variables being shown to be the main influences on fenestration ratios in England.

Variables for SAP calculation: The area of windows in each dwelling having different U-values was calculated using the following WHCS variables:-

- The fenestration ratio (imputed from the EHCS as above)
- Number of windows of each of seven types in the front and back views (WPS.6.8)
- Whether these windows had faults (WPS 6.8).
- Total door area (derived from WPS.6.9 as above).
- Total wall area, including doors and window (WPS derived)
- Type of flat (WPS2.3)
- Type of common parts (WPS 4.1)
- Number of floors in block (WPS 4.13)
- Average floor height (derived at SAP 6 above)
- Number of dwellings in block (WPS 4.13)

Methodology: For houses, the average area per window was calculated from the imputed fenestration ratio, the total wall area (including doors and windows), the total door area and the total number of windows in the dwelling. In the case of flats, the WHCS records the total wall area for the whole flat block and consequently an allowance was made for the elevational area of any common parts, depending on the type of flat (converted or purpose built), the type of common parts recorded, the number of flats in the block, the average floor height and the height of the block. After allowing for common parts, the elevational area of the individual flat was determined from the total wall area and number of flats in the block, and the average area per window then calculated as for a house.

As for doors, the number of windows of each frame and glazing type (wood, UPVC, metal or other and single or double glazed) that were either sound or had faults was determined. The total window area was then calculated for each type and condition, from the number and average window area. Using SAP Table 6b *Indicative U-values (W/m^2K) for windows, doors and roof-lights*, appropriate U-values using a total of 14 different values, were then assigned to each window area, depending on the window type and condition.

SAP calculations:- The heat loss from windows for each single glazed and double glazed window type was then calculated as follows:-

(SAP27) Heat loss, s.g. windows = 0.9 x Area of window/s (m^2) x U-value (W/m^2K).
(SAP28) Heat loss, d.g. windows = 0.9 x Area of window/s (m^2) x U-value (W/m^2K).

Assumptions: The above methodology included the following main assumptions, namely that:-

- Where the dwellings have windows of more than one type, these have similar average areas.
- The elevational area of the sample flat is average for all flats in the block.
- The fenestration ratio of the sample flat is similar to that for the whole block.
- Common main entrances to flats have an elevational area of 2.0 m x av. room height.
- Common stairs only have elevational areas in purpose-built flats with an average of more than one dwellings per floor.
- The total elevational area of the common parts is then equal to 2.0 m x av. floor height x number of floors.
- Windows with faults are older and have a slightly higher/worse average U-value than those of the same recorded type that have no faults.

c) Roof-lights

SAP (29): required the area and U-values for any roof-lights in each dwelling.

Variables for SAP calculation: The area of any roof-lights in each dwelling having different U-values was calculated using the following variables:-

- Top room inspected (as derived at SAP 11-12 above)
- Number of windows recorded internally (WPS 3.6)
- Total number of windows recorded externally (derived from WPS 6.8)
- Attic room conversion (WPS 3.26)

Methodology: Where windows in an attic room were recorded and the total number of windows recorded internally was greater than the number recorded externally, the number of additional windows was assumed to be roof-lights. The total area of these roof-lights was calculated, assuming an average area of 1 square metre per window. Using SAP Table 6b *Indicative U-values (W/m^2K) for windows, doors and roof-lights*, an appropriate U-values was assigned to each roof-light, assuming these to be of the 'Velux' type.

SAP calculation:- The heat loss from any roof-lights was then calculated as follows:-

(SAP29) Heat loss, roof-lights **=** 0.9 x Area of roof-light/s (m^2) x U-value (W/m^2K).

Assumptions: The methodology included the following main assumption, namely that:-

- Where an attic conversion was inspected, a higher count of windows internally than externally, indicated the presence of roof-lights.
- The average area of each roof-light was 1 square metre.
- The roof-lights had a wooden frame and were double glazed with a 6mm air gap.

d) Ground floor
SAP (30): required the area and U-values for the different types and insulation standards of the ground floors in each dwelling.

Variables for imputing ground floor fraction: The proportion of the total floor area on the ground/basement floor was imputed from the EHCS using the following EHCS and WHCS variables:-

- *Ground floor/basement fraction (derived from EPS 8 & 13)*
- Dwelling type (E derived & WPS.2.3 & WIS.B)
- Number of floors in dwelling (EPS 8 & 13 & W derived, as at SAP 11/12 below)
- Whether attic and/or basement present (E derived & WPS 3.26)
- Date of construction (EPS 4 & WPS 2.5)

Methodology: Using the EHCS sample, the average area of the ground floor as a proportion of the total floor area was determined for each dwelling. Regression analysis was then used to determine from a longer list of potentially relevant variables, the above common variables as the main EHCS/WHCS variables influencing this proportion/ground floor fraction. With these variables, a typology of dwelling 'types', where similar ground floor fractions might be expected, was constructed for both the EHCS and WHCS samples. For the EHCS sample, the standard deviation for the ground floor fractions for each dwelling category was checked to ensure that these were tightly distributed. Finally, the mean proportion/ground floor fraction for each dwelling category was then assigned to the same dwelling categories in the WHCS.

Assumption: The methodology was based on the following main assumption, namely that:-

- Dwellings in Wales and England of the same type, floor number and type and date of construction have a similar proportion of their total floor area at ground level, these variables being shown to be the main influences on this ground floor fraction in England.

Variables for SAP calculation: The areas and different types and insulation standards of the ground/basement floors in each dwelling were determined using the following WHCS variables:-

- Ground floor/basement fraction (imputed from the EHCS as above)
- Total SAP related floor area (imputed from the EHCS as in SAP 1-5 above)
- Presence of solid floors (WPS 3.3)
- Whether the floors had faults (WPS 3.3).
- Level of recorded room (WPS 3.1B)
- Date of construction (WPS 2.5)
- Predominant wall structure (derived from WPS 6.5)
- Heating system (derived from WPS 3.24 & 3.25)
- Insulation standards (derived from WIS 1.12 & WPS 3.25 & 6.8)

Methodology: The total ground floor/basement area was calculated from the ground floor fraction, imputed as above, and from the total SAP related floor area of

each dwelling. The approximate proportion of the total ground floor with solid and suspended floors was determined from the number of ground floor/basement rooms recorded and the number with solid floors. This enabled the calculation of the area of the solid and/or suspended ground floors in each dwelling.

With little detailed information on the floors from the WHCS, the type of solid and/or suspended floors in each dwelling and their insulation standards was determined according to whether the floor had faults, the date of construction of the dwelling, the type of wall structure, the efficiency of the heating system and general insulation standards of the dwelling. The U-Values for typical solid and suspended floor constructions and thickness was determined using NHER Builder and 6 different U-values assigned to the solid and/or suspended floors in each dwelling. (See Annex C)

SAP calculations:- The heat loss from ground floors for each type of floor and insulation standard was then calculated as follows:-

(SAP30) Heat loss from floors **=** Area of floors/s (m^2) x U-value (W/m^2K).

Assumptions: The methodology included the following assumptions, that:-

- The proportion of all ground floor/basement rooms recorded with solid floors was representative of the area of the ground floor with solid floors.
- Timber frame dwelling built post 1964 have a high standard of floor insulation.
- Dwellings built post 1964 with higher efficiency boilers and high general standards of insulation have a high standard of floor insulation.
- Other dwellings with higher efficiency boilers and high general standards of insulation have some applied floor insulation.
- All other dwellings have no floor insulation, other than that provided by the floor construction.
- There is no heat loss through the floors of flats not at ground floor or basement level.

e) External walls

SAP (31-32): required the area and U-values for the different types of external wall in each dwelling.

Variables for imputing wall insulation where not known: The presence of wall insulation in non-cavity walls and in the large proportion of cavity walls where insulation was not known was imputed from the EHCS using the following EHCS and WHCS variables:-

- *Cavity wall insulation (EPS 16)*
- *External wall insulation (EPS 16)*
- *Over-cladding (EPS 15)*
- *Dry lining present (EPS 5)*
- Predominant wall structure (EPS 14 & derived from WPS 6.5)
- Tenure (E derived and WIS derived)
- Dwelling type (E derived & WPS.2.3 & WIS.B)
- Date of construction (EPS 4 & WPS 2.5)
- Type of heating (EPS 5 & WPS 3.24 & 3.25)
- Loft insulation thickness (EPS 6 & WPS 3.26)

Methodology: Using the EHCS sample, regression analysis was used to determine from a longer list of potentially relevant variables, the above common variables as the main EHCS/WHCS variables predicting the presence of wall insulation of different types. With these variables, a typology of dwelling/heating 'types', where wall insulation might be expected, was constructed for both the EHCS and WHCS samples. For the EHCS sample, the frequency of wall insulation for each of these dwelling categories was checked to ensure that these were high. Finally, the presence of wall insulation was assigned to the same dwelling categories in the WHCS.

Assumption: The above methodology was based on the following main assumption, namely that:-

- Dwellings in Wales and England of the same wall type, tenure, dwelling type, date of construction, heating type and loft insulation standards have similar levels of wall insulation, these variables being shown to be the strongest predictors of wall insulation in England.

Variables for SAP calculation: The area of external walls in each dwelling having different U-values was calculated using the following WHCS variables:-

- Area of wall structures of each of nine types in the front and back views (WPS.6.5)
- Area of wall finishes of each of eight types in the front and back views (WPS.6.6)
- Presence of full or partial cavity wall insulation (WIS 1.12)
- Presence of cavity and other wall insulation (imputed from EHCS as above)
- Date of construction (WPS 2.5)
- The fenestration ratio (imputed from the EHCS as in SAP 27-28 above)
- Elevational area of common parts (as derived at SAP 27-28 above)

Methodology: Where householders reporting having all cavity walls insulated, all walls were taken as insulated. Where households only reported some walls insulated, cavity walls, pre-cast concrete, timber and metal sheet walls were assumed to have 'cavity' insulation in dwellings where not all walls were of these types. Where the households reported no cavity insulation and the predominant wall structure was cavity, the dwelling was taken as having no wall insulation, but elsewhere wall insulation was assumed if indicated as likely by the imputed insulation variable. Similarly, in the large proportion of cases coded as 'not known' or 'not applicable' in the WIS, the imputed variable was used to determine wall insulation. In keeping with the higher proportion of cavity insulation recorded by the WHCS, this gave slightly higher levels of external wall insulation or dry-lining than for England.

The actual wall construction (excluding insulation) was determined directly from the WHCS data on the type of wall structure and type of wall finish in each dwelling. However, the actual materials and thicknesses assumed were also varied with the date of construction, having reference to books on building construction from the inter-war and post war years. With the presence or otherwise of applied cavity and external insulation or dry-lining, determined as above, the total number of wall

constructions used was 45 types, NHER Builder being used to determine the U-values for each of these types (See Annex C).

For houses, the total elevational area for each wall type was determined from the WHCS data on the area of each wall structure. However, as this included doors and windows, the wall areas alone were determined using the imputed fenestration ratio. For flats, the elevational area of all the dwellings was reduced by the elevational area of the common parts (determined as in SAP 27-28 above) and the wall area of the sample flat then calculated from both the fenestration ratio and the number of flats in the block.

SAP calculations:- The heat loss from external walls for each type of masonry and other wall type and insulation standard was then calculated as follows:-

(SAP31) Heat loss from masonry walls **=** Area of wall/s (m^2) x U-value (W/m^2K).

(SAP32) Heat loss from other wall types **=** Area of wall/s (m^2) x U-value (W/m^2K).

Assumptions: The above methodology included the following assumptions; that:-

- The assumptions regarding wall insulation stated in the first paragraph above hold true.
- Where the dwellings have walls of more than one type, these have similar fenestration ratios.
- The elevational area of the sample flat is average for all flats in the block.
- The fenestration ratio of the sample flat is similar to that for the whole block, including the elevation of the common parts.

f) Roofs

SAP (33-34): required the area and U-values for the different types of roof in each dwelling.

Variables for SAP calculation: The area of roof in each dwelling having different U-values was calculated using the following WHCS variables:-

- Area of roof structures of each of seven types in the front and back views (WPS.6.2)
- Area of roof covering of each of eight types in the front and back views (WPS.6.6)
- Presence and thickness of loft insulation (WPS 3.26)
- Date of construction (WPS 2.5)
- Total floor area (as imputed at SAP 1-5 above)
- Dwelling type (WPS.2.3 & WIS.B)

Methodology: Roof constructions were determined for each dwelling from the WHCS data on seven types of the roof structure and eight types of roof covering. Roof insulation was determined from the WHCS question on the presence and thickness of loft insulation. However, this data was enhanced in line with the distribution of the finer gradation of insulation thickness provided by the EHCS, dependent on factors such as the date of construction. In total, with these different insulation standards and the different roof structures and coverings, a total of 54 roof

constructions were use. Again, NHER Builder was used to determine the U-values for each of these roof categories (See Annex C).

For houses, the total area for each roof construction was determined directly from the WHCS data on the area of the roof structures, after deducting the area of any roof-lights determined at SAP 29 above. The roof area for top floor flats was determined from their floor area. Using the sample of mid terrace single storey bungalows with pitched roofs, the average 'pitch factor' by which the roof area was larger than the total floor area was determined, for each dwelling age (the latter being used as a proxy for the roof pitch). The relative proportion of any flat and/or pitched roof for the block was determined and assumed to apply to the top floor flat. These proportions were then applied to the area of the dwelling, to compute the area of any flat roof and the area of any pitched roof. The latter was calculated by applying the 'pitch' factor appropriate to the date of construction.

SAP calculations:- The heat loss from roofs for each type of pitched and flat roof and insulation standard was then calculated as follows:-

(SAP33) Heat loss from pitched roofs **=** Area of roof/s (m^2) x U-value (W/m^2K).
(SAP34) Heat loss from flat roofs **=** Area of roof/s (m^2) x U-value (W/m^2K).

Assumptions: The above methodology included the following assumptions, namely that:

- Within the broader insulation thickness categories recorded by the WHCS, loft insulation standards were distributed as in the EHCS.
- In flats, the relative proportion of, say, pitched to flat roof etc, for the block can generally be also applied to any sample top floor dwelling/s.
- The date of construction provides a reasonable proxy for the average roof pitch.
- There is no heat loss through the ceilings of flats not on the top floor of a block.

g) Other

SAP (35): required the area and U-values for other elements, including non-separated and heated conservatories.

SAP calculations:- It was assumed that there were no other significant heat losses
(SAP35) Other heat losses = 0.

Assumptions: It is assumed that conservatories are separated from the dwelling, eg, by a door, and are unheated and that there are no other significant heat losses.

h) Heat loss calculations

SAP (36-38): No additional information is required for these final heat loss calculations.

SAP calculations:- The heat loss coefficient (in W/K) and heat loss parameter HLP (in W/m^2K) were then calculated as follows:-

(SAP36) Ventilation heat loss = SAP25 x 0.33 x SAP6.
(SAP37) Heat loss coefficient = SAP26+SAP27+SAP28+SAP29+SAP30+SAP31+ SAP32+SAP33+SAP34+SAP35 SAP35+SAP36.
(SAP38) Heat loss parameter (HLP) = SAP37/SAP5.

4. WATER HEATING ENERGY REQUIREMENTS

a) Distribution losses etc

SAP (39-43): requires hot water usage, tank volume and tank insulation thickness.

Variables for imputing hot water cylinder volume: The volume of any hot water cylinder was imputed from the EHCS using the following EHCS and WHCS variables:-

- *Volume of hot water cylinder (EPS 16)*
- Water heating system (WPS 3.25)
- Water heating fuel (WPS 3.24 & 3.25)
- Tenure (E derived and WIS derived)
- Dwelling type (E derived & WPS.2.3 & WIS.B)
- Number of habitable rooms (E derived & WIS 3.1A)

Methodology: The EHCS sample categorizes hot water cylinder sizes into three volumes, 120, 140 and 210 litres. Regression analysis was used to determine from a longer list of potentially relevant variables, the above common variables as the main EHCS/WHCS variables predicting the size of the hot water cylinder. With these variables, a typology of dwelling/heating 'types', where different sizes of cylinder might be expected, was constructed for both the EHCS and WHCS samples. For the EHCS sample, the frequency of each cylinder size in each dwelling category was checked to determine the predominance of a particular size in each category. Finally, the predominant size was assigned to the same dwelling categories in the WHCS.

Assumption: The above methodology was based on the following assumption, namely that:-

- Dwellings in Wales and England of the same tenure, dwelling type, number of habitable rooms and with the same water heating system and fuel have the same predominant size of hot water cylinders, these variables being shown to be the strongest predictors of cylinder sizes in the EHCS.

Variables for SAP calculation: the hot water usage, hot water tank volume and tank insulation thickness, were calculated using the following WHCS variables:-

- Total floor area (imputed from the EHCS as in SAP 1-5 above)
- Hot water cylinder volume (imputed from the EHCS as above)
- Hot water system (WIS 1.12)
- Central heating system (WPS 3.24 & WIS 1.14)
- Presence of hot water cylinder insulation (WPS 3.25)
- Presence of primary pipe-work insulation (WPS 3.25)
- Date of construction (WPS 2.5)

Methodology: The hot water energy requirement was determined from the imputed total floor area (TFA) using the algorithm for SAP Table1 column (a):-

Hot water usage = [(61 x N) + 92] x 0.85 /31.71, where N = 0.035 x TFA – 0.000038 x TFA^2, if TFA <= 420 or N = 8.0, if TFA > 420.

To calculate the distribution loss where a hot water cylinder was present or the dwelling had community heating, the algorithm for SAP Table1 column (b) was used:-

Distribution loss = [(61 x N) + 92] x 0.15 /31.71, where N is calculated as for the hot water usage.

In accordance with the SAP procedure, a nil distribution loss was used where the WHCS indicated a separate instantaneous water heater. Where present, the hot water cylinder volume was determined from the variable imputed from the EHCS, and, in accordance with SAP, a volume of 110 litres used where there was community heating and no tank.

Following an analysis of the 1996 EHCS, the type and thickness of any cylinder insulation recorded as present was assumed to reflect the type of hot water system, standard of pipework insulation and date of construction. Thus, where hot water was provided by a higher efficiency central heating boiler and primary pipework insulation was present, the cylinder was assumed to be factory insulated with a 25mm jacket. Where the CH boiler provided the hot water and the dwelling was post 1964, the cylinder was assumed to be factory insulated with a thickness of 7.5mm. Where the hot water was not provided by central heating, any insulation was taken to be a loose jacket, 12.5mm thick. Other intermediate systems were assumed to have a loose jacket, 25mm thick, except where no insulation was recorded. Using these assumptions, the hot water loss factor was computed using the appropriate one of 11 SAP Table 2 algorithms. For community heating but no tank a factor of 0.0079 was used, as advised by SAP.

SAP calculations:- the distribution losses (in GJ/year) were then calculated as follows:-

(SAP39) Hot water energy requirement = as calculated above (Table 1 col (a)).
(SAP40) Distribution loss = as calculated above (Table 1, column (b))
(SAP41) Hot water storage volume (litres) = imputed cylinder volume.
(SAP42) Hot water storage loss factor = as calculated above (Table 2).
(SAP43) Energy loss from hot water storage = SAP41 x SAP42.

Assumptions: The above methodology included the following assumptions, namely that:

- The type and thickness of any cylinder insulation related to the type of hot water system, standard of pipework insulation and date of construction as in the EHCS.

b) Solar panels

SAP (44-47): requires the area of any solar panels.

SAP calculations:- Assuming no solar panels:-

(SAP44) Area of solar panels = 0.
(SAP45) Solar energy available = 0.
(SAP46) Load ratio = 0.
(SAP47) Solar input = 0.

Assumption: It is assumed that no solar panels are present in the 1997/98 WHCS sample. (After grossing, the 1996 EHCS showed that less than 0.5% of homes had solar panels).

c) Primary circuit loss and efficiency of water heater
SAP (48-52): requires details of the boiler or heater type and on the presence of primary pipe-work insulation and cylinderstats. .

Variables for SAP calculation: Details of the boiler or heater type, any primary pipe-work insulation and cylinderstats were determined from the following WHCS variables:-

- Hot water system (WIS 1.12)
- Central heating system (WPS 3.24 & WIS 1.14)
- Whether central heating outlets in each room (WPS.3.7)
- Whether fixed other heaters in each room (WPS.3.7)
- Presence of primary pipe-work insulation (WPS 3.25)
- Data on other insulation standards (WPS 3.26 & 6.8 & WIS 1.12)

Methodology: The primary circuit losses were computed, using SAP Table 3: *Primary circuit losses*, from the WHCS data on the main type of hot water system, including whether from a community heating scheme, and from the presence of primary pipe-work insulation and cylinderstats. Cylinderstats were assumed to be present only where the data indicated a high efficiency boiler and the highest standards of general insulation, these occurring most frequently in recently built housing.

The efficiency of the water heater was determined, using the values in SAP Table 4a*; Heating system seasonal efficiency*, adjusted where appropriate for heating controls, by the amounts show in Table 4e *Heating system controls.* Heating controls were determined as described at section 7(a) (SAP71-74) below.

In the majority of cases where the hot water was provided by the central heating boiler, the efficiency of the water heater was taken as the same as the efficiency of main heating system and how this was determined is also detailed at 7(a) (SAP71-74) below. Where the water heating was separate, the system was determined from the information in the WHCS (WPS 3.24). However, where the type of system was know, (eg, an instantaneous heater) but not the fuel, the latter was assumed to be gas where the main heating was gas and electric where the main heating was some other fuel. Given that many houses had more than one system, for example a boiler system and an immersion heater, these were treated as hierarchical, the primary hot water system being assumed to be the central heating system, other boiler system, instantaneous heater or immersion heater, in that order.

SAP calculations:- the total output from the water heater (in GJ/year) and the total heat gains from water heating were calculated as follows:-

(SAP48) Primary circuit losses = as determined above (Table 3).
(SAP49) Output from water heater = SAP39+SAP40+SAP43+SAP48 – SAP47
(SAP50) Efficiency of water heater % = as determined above (Table 4 (a) & (e))
(SAP51) Energy required for water heating = (SAP49 x 100) / SAP50.
(SAP52) Heat gains, water heating = (0.25xSAP39)=0.8(SAP40+SAP43+SAP48)

Assumptions: The above methodology included the following assumptions, namely that:

- Cylinderstats were associated with a high efficiency boiler and the highest standards of general insulation.
- Where the water heating was not from a CH boiler or an immersion heater, the fuel type was assumed to be the same as for the space heating.
- Immersion heaters etc were not the main form of water heating where other systems were present.

5. INTERNAL GAINS

SAP (53-55): requires data on internal gains from lights, appliances, cooking, and on metabolic gains.

Variables for SAP calculation: Internal gains from lights, appliances, cooking, and metabolic gains were determined from the following variable:-

- Total floor area (as imputed from the EHCS at SAP 1-5 above).

Methodology: Internal gains (in Watts) for each dwelling was computed from the total floor area (TFA) using the SAP Table 5 algorithm, as follows:-

Gains (W) = 74 + 2.66 x TFA + 75.5 x N, if TFA <= 282.
Gains (W) = 824 + 75.5 x N, if TFA > 420.

where N = 0.035 x TFA – 0.000038 x TFA^2, if TFA <= 420 or N = 8.0, if TFA > 420. Except where there was community heating or solid fuel back boilers, an additional 10 W was allowed for central heating pumps, as advised by SAP.

SAP calculations:- the total internal gains (in Watts) were computed as follows:-

(SAP53) Lights, appliances, cooking & metabolic = as calculated above (Tab 5).
(SAP53a) Additional gains = as determined above (Table 5 note).
(SAP54) Water heating = 31.71 x SAP52.
(SAP55) Total internal gains = SAP53+SAP53a+SAP54).

Assumptions: There were no assumptions needed at this stage, other than those concerning the imputing of the total floor areas as already stated at SAP 1-5.

6. SOLAR GAINS

SAP (56-70): requires window area by orientation of window, solar flux dependent on glazing type (including if low emissivity) and extent of overshadowing

Variables for SAP calculation: The area of windows, glazing type and extent of overshadowing were calculated using the following variables:-

- Areas of single and double glazed windows (derived as at SAP 27-28 above)
- Area of roof-lights (derived as at SAP 29 above)

Methodology: As advised by the SAP procedure in cases where the orientation is unknown, all dwellings were assumed to be oriented East/West, the windows on the front view facing East and those on the back view facing West. As also advised by SAP, roof-lights were assumed to be 'horizontal'. The solar flux for each window type and any roof-lights was then determined from SAP table 6, *Solar flux through glazing (W/m^2).* The solar access factor was assumed to be 1.0, as advised by the SAP procedure where the extent of overshadowing is unknown.

The total gains were determined by adding the internal and solar gains and the sum divided by the heat loss coefficient determined in section 3 above, to give the gain/loss ratio (GLR). From this the utilisation factor was determined using SAP Table 7: *Utilisation factor as a function of gain/loss ratio,* and finally the Useful Gains calculated.

SAP calculations:- the solar gains (in Watts) were calculated for the orientation and the total useful gains then computed as follows:-

(SAP56/57) North/North east = 0.
(SAP58) East = Area (m^2) x Flux (determined as above).
(SAP59-61) South east/South/South west = 0.
(SAP62) West = Area (m^2) x Flux (determined as above).
(SAP63) North west = 0.
(SAP64) Roof-lights = Area (m^2) x Flux (determined as above).
(SAP64a Total = SAP58+SAP62+SAP64.
(SAP65) Solar access factor = 1 (determined as above).
(SAP66) Solar gains (standard location) = SAP64a x SAP65.
(SAP67) Total gains, W = SAP55 + SAP66.
(SAP68) Gain/loss ratio (GLR) = SAP67 / SAP37.
(SAP69) Utilisation factor = determined as above (using Table 7)
(SAP70) Useful gains, W = SAP67 x SAP69.

Assumptions: The above methodology included the following assumptions, namely that:

- All dwellings were oriented East/West (as advised by the SAP procedure)
- No dwellings had low-emissivity double glazing, such glazing being relatively rare prior to 1997.
- The solar access factor for overshadowing was 1.0 (as advised by SAP)

7. MEAN INTERNAL TEMPERATURE

a) Mean internal temperature

SAP (71-74): requires type and responsiveness categories for heating system and control category for heating controls and the area of Zone 1 (living area) relative to total floor area of the dwelling.

Variables for SAP calculation: Details of the heating system and heating controls were determined from the following WHCS variables:-

- Central heating system (WPS 3.24 & WIS 1.14)
- Whether central heating outlets in each room (WPS.3.7)
- Whether fixed other heaters in each room (WPS.3.7)
- Water heating system (WPS 3.25)
- Presence of hot water cylinder (WPS 3.25)
- Date of construction (WPS 2.5)

Methodology: A new 21 category variable for the main heating system in the dwelling was computed. This used the WHCS data on central heating fuels and on the fuel for other fixed heating, where there was no central heating present. However, the central heating categories were further expanded. For systems fired by gas, LPG and fuel oil, the boiler was assumed to be a combination boiler where hot water was provided by the central heating but there was no hot water cylinder present. For gas, LPG and solid fuel central heating, a back boiler was assumed where the fuel for the fixed heating was the same as for the central heating, but in the main lower floor rooms or kitchen only fixed heating was recorded (as instructed for back boilers in the WHCS surveyors manual). Where the main heating was a solid fire or stove and a boiler was specified for the water heating, this was also assumed to be a back-boiler.

Following an analysis of the 1996 EHCS data on heating controls, likely heating controls for each dwelling were determined from the type of the space and water heating present and date of construction of the dwelling, the more modern and efficient heating types being assumed to have the more sophisticated controls.

The mean internal temperature of the living area was determined using SAP Table 8; *mean internal temperature of the living area,* from the SAP 'heating type' for the main heating system (as given in SAP Table 4a*: Heating systems seasonal efficiency*) and the Heat Loss Parameter, calculated in section 3 above. Temperature adjustments for the heating controls were made using SAP Table 4e *Heating system controls*. The responsiveness (R) of the heating system was determined from SAP Tables 4a and Table 4d; *Heating type and responsiveness for gas and oil boilers.* The temperature difference between zones was determined using SAP Table 9*; Difference in temperatures between zones*, from the SAP 'control type' for the heating system controls (as given in SAP Table 4e) and the Heat Loss Parameter (HLP = SAP38).

SAP calculations:- the adjusted living room temperature and temperature difference between zones was computed as follows:-

(SAP71) Mean internal temperature of living room = as above (from Table 8).
(SAP71a) Temperature adjustment = determined as above (from Table 4e).
(SAP72) Adjustment for gains = ((SAP70 / SAP37) – 4.0) x 0.2 x R (as above).
(SAP73) Adjusted living room temperature = SAP71 + SAP71a + SAP72.
(SAP74) Temperature difference between zones = as above (from Table 9).

Assumptions: The above methodology included the following assumptions, namely that:

- The assumptions regarding combination and back-boiler specified in the first paragraph above holds true.
- The type of heating controls relates to the type of space and water heating and date of construction, as in the EHCS.

b) Living area fraction

SAP (75-77): requires the area of the living room relative to total floor area of the dwelling.

Variables for SAP calculation: The area of the living room relative to total floor area of the dwelling was determined from the following variables and information:-

- Total floor area (imputed from the EHCS as in SAP 1-5 above)
- Dwelling plans, from numerous sources, covering all main tenures, dwelling types, ages and size of dwelling.

Methodology: The living room fraction**,** that is the area of the living room as a proportion of the total floor area, was determined from a detailed examination of typical dwelling plans from numerous sources, covering all main tenures, dwelling types, ages and size of dwelling. While the size of living rooms varied widely, the fraction these were of the total floor area of the dwelling was found to be much more tightly distributed, particularly when this was controlled for the total number of habitable rooms. From these plans, a total of nine average living room fractions were calculated for dwellings with 1 to 9 or more habitable rooms, this fraction progressively decreasing with dwelling size.

SAP calculations:- the mean internal temperature was computed as follows:-

(SAP75) Living area fraction = determined as above.
(SAP76) Rest of house fraction = 1 – SAP75.
(SAP77) Mean internal temperature = SAP73 – (SAP74 x SAP76).

Assumptions: The above methodology included the following assumptions, that:-

- The typical dwelling plans from which the living area fraction was determined are representative of housing in Wales.

8. DEGREE-DAYS

SAP (78-80): calculates the Degree Days.

Variables for SAP calculation: No further primary data needed for these stages.

Methodology: The Degree Days is determined from the Base Temperature, using SAP Table 10: *Degree days as a function of base temperature*.

SAP calculations:- the base temperature and degree days was computed as follows:-

(SAP78) Temperature rise from gains = SAP70 / SAP37.
(SAP79) Base temperature = SAP77 – SAP78.
(SAP80) Degree days = determined as above (from Table 10).

Assumptions: No assumptions needed.

9A. SPACE HEATING REQUIREMENT – CONVENTIONAL HEATING

After calculating the Energy Requirement, a different SAP procedure is used for conventional heating systems than for community heating.

SAP (81-87): requires data on the use of secondary heating systems for each main system, the efficiency of main heating & secondary systems, and electricity for pumps & fans obtained from data on system type and dwelling volume, where relevant.

Variables for SAP calculation: Details of the primary and secondary heating systems were determined from the following WHCS variables:-

- Central heating system (WPS 3.24 & WIS 1.14)
- Other fixed heating (WPS 3.24)
- Whether central heating outlets in each room (WPS.3.7)
- Whether fixed other heaters in each room (WPS.3.7)
- Data on insulation standards (WPS 3.25, 3.26 & 6.8 & WIS 1.12)
- Date of construction (WPS 2.5)

Methodology: Many centrally heated dwellings have fixed other heaters, such as open fires, which are rarely if ever used. Consequently, where a central heating outlet was recorded in every inspected room, it is assumed that there is no secondary heating. Elsewhere, the fraction of heating supplied by the secondary system was determined, using SAP Table 11*: Fraction of heat supplied by secondary heating system*, from the presence of both central heating and other fixed heating or, where there is no central heating, from the presence of fixed heaters in more than one room. In the latter case, it is assumed that the fuel for the secondary heaters is the same as that for the main fixed heating.

The main heating system and the heating controls were determined as described in section 7a (SAP 71-74) above. From this data the efficiency of the main heating system was determined, using the values in SAP Table 4a*; Heating system seasonal*

efficiency or Table 4b: *Seasonal efficiency for gas and oil boilers,* adjusted where appropriate for heating controls, by the amounts show in Table 4c and Table 4e. Similarly, the efficiency of the secondary heating system was determined, using the values obtained from SAP Table 4a.

All central heating systems, fuelled by gas, LPG, solid fuel and fuel oil, where a water-borne distribution system was most likely, were assumed to have a central heating pump, apart from solid fuel back-boiler systems. A few dwellings with the highest efficiency boilers and the highest levels of insulation were assumed to have boilers with fan-assisted flues. However, it was assumed that there were no dwellings in the sample with whole-house mechanical ventilation, this being rare before 1997.

SAP calculations:- the energy requirement, the efficiency of the heating systems and electricity for pumps and fans (in GJ) were computed as follows:-

(SAP81) Energy requirement = 0.0000864 x SAP80 x SAP37.
(SAP82) Fraction of heat from secondary system = as above (from Table 11).
(SAP83) Efficiency of main heating system = as above (from Tables 4 (a)-(e))
(SAP84) Efficiency of secondary heating = determined as above (Tables 4 (a))
(SAP85) Space heating fuel (main) = (1 – SAP82) x SAP81 x 100 / SAP83.
(SAP86) Space heating fuel (secondary) = (SAP82 x SAP81) x 100/ SAP84.
(SAP87a) Electricity for central heating pumps = 0.47 (where appropriate).
(SAP87b) Electricity for boiler with fan-assisted flue = 0.16 (where appropriate)
(SAP87c) For warm-air heating system fans = 0.002 x SAP6 (where appropriate)
(SAP87d) For whole house mechanical ventilation = 0 (see above).
(SAP87) Total electricity for pumps and fans = SAP87a+SAP87b+SAP87c.

Assumptions: The methodology included the following assumptions, that:-

- Dwellings with central heating outlets in all inspected rooms had no secondary heating system in regular use.
- Where no central heating, the primary and secondary heating systems use the same fuels.
- That all potential water-borne systems had a central heating pump, apart from solid-fuel back boiler systems.
- Fan assisted flues were associated with higher efficiency boilers and high levels of general insulation.
- No dwellings in the sample had a whole-house mechanical ventilation system.

9B. SPACE HEATING REQUIREMENT – COMMUNAL HEATING

SAP (82-87): requires data on the communal heating system.

Variables for SAP calculation: Details of the communal heating system were determined from the following WHCS variables:-

- Presence of community heating (WIS 1.14)

Methodology: From Table 4 (a), the efficiency was determined as 100%, assuming the system to be a central heating system with radiators, and as requiring no adjustment having a programmer and TRVs. However, the system was assumed

not to be CHP. The distribution loss factor was determined from SAP Table 12a: *Distribution loss factor for group and community schemes,* assuming it to be a mains piping system installed in 1990 or earlier, not pre-insulated, and with full flow, medium or high temperature distribution. Communally heated dwellings were assumed not to have whole-house mechanical ventilation.

SAP calculations:- the efficiency of the communal systems, energy for the space heating and electricity for pumps and fans (in GJ/year) were computed as follows:-

(SAP82) Overall system efficiency = 100 (from Table 4e).
(SAP83) Fraction of heat from CHP unit = 0 (assuming no CHP)
(SAP84) Fraction of heat from boilers = 1 – SAP83.
(SAP85) Distribution loss factor = 1.20 (determined as above from Table 12a)
(SAP86) Space heating from CHP = 0 (assuming no CHP)
(SAP87) Space heating from boilers = (SAP81xSAP84x100) / (SAP82xSAP85).
(SAP88) Electricity for pumps and fans = 0 (assuming no full mech. ventilation)

Assumptions: The methodology included the following assumptions, that:-

- The assumptions regarding the type of communal heating system as outlined in the methodology above hold true.

10A. FUEL COSTS – CONVENTIONAL HEATING

SAP (88-97): requires fuel type for main and secondary heating and for water heating.

Variables for SAP calculation: Details of the fuel used were determined from the following WHCS variables:-

- Extended central heating variable (derived from WHCS as at SAP 71-74 above)
- Extended other fixed heating variable (derived from WPS 3.24)
- Location, urban or rural (WPS 7)
- Extended water heating system variable (derived from WPS 3.25)
- Hot water cylinder volume (imputed from the EHCS as at SAP 39-43 above)

Methodology: Unit fuel prices were attributed to each fuel used for the main and secondary heating systems, using the values in SAP Table 12: *Fuel prices and additional standing charges*. For central heating, 'Other fixed gas' was assumed to be bulk LPG while 'LPG/bottled gas' was assumed to be 'Bottled gas – propane 47g cylinders'. Electric storage heaters were assumed to be 'off-peak' and other electric central heating on a '24 hr heating tariff'. Solid fuel central heating, without a back boiler, was assumed to use anthracite nuts, while all solid fuel fires and stoves were assumed to use smokeless fuel, if in an urban location, and house coal or wood in a rural location. For other fixed heating, 'other fixed gas' was assumed to be 'Bottled gas – propane 47g cylinders', while 'electric fixed' was assumed to be on a standard tariff. Any additional standing charges were also obtained from SAP table 12.

From the water-heating variable, developed at SAP 48-52 above, electric instantaneous and immersion heaters were assumed to be on standard tariff, while all other electric systems were assumed to have on-peak and off-peak prices. The

on-peak fraction for this water heating was determined using the SAP Table 13 algorithm as follows:-

Fraction = (14530 – 762N)/V – 80 + 10N, where N = 0.035 x TFA – 0.000038 x TFA^2, if TFA <= 420 or N = 8.0, if TFA > 420 and V = Volume of HW tank.

SAP calculations:- the fuel costs for the space and water heating systems (in £/year) were computed as follows:-

(SAP88) Space heating, main system = SAP85 x fuel price (from Table 12).
(SAP89) Space heating, secondary system = SAP85 x fuel price (Table 12).
(SAP90) Electric water heating, on-peak % = as determined above (Table 13).
(SAP91) Off-peak percentage = 100 – SAP90.
(SAP92) On-peak costs = (SAP51 x SAP90)/100 x fuel price (from Table 12).
(SAP93) Off-peak costs = (SAP51 x SAP91)/100 x fuel price (from Table 12).
(SAP94) Other water heating costs = SAP51 x fuel price (from Table 12).
(SAP95) Pump and fan energy costs = SAP87 x fuel price (where appropriate).
(SAP 96) Additional standing charges = as determined above (from Table 12).
(SAP97) Total heating = SAP88+SAP89+SAP92+SAP93+SAP94+SAP95+ SAP96.

Assumptions: The methodology included the following assumptions, that:-

- The assumptions regarding the particular type of fuel used as outlined in the first paragraph above hold true.
- Instantaneous and immersion heaters were on standard tariff and only other electric water heating systems used on-peak and off-peak tariffs.

10B. FUEL COSTS – COMMUNAL HEATING

SAP (89-97): requires fuel type for the communal space and water heating.

Variables for SAP calculation: Details of the communal heating system were determined from the following WHCS variables:-

- Presence of community heating (WIS 1.14)
- Central heating system fuel (WHS 3.24)
- Extended water heating system variable (derived from WPS 3.25)

Methodology: As above, the communal heating system was assumed not to be CHP. Whether the water was heated by immersion heater was determined from the derived, extended water heating variable, described in section 4c (SAP48-52) above. When associated with communal heating, immersion heaters were assumed to use off-peak tariff, when available, and the on-peak fraction was determined using the SAP Table 13 algorithm as follows:-

Fraction = (14530 – 762N)/V – 80 + 10N, where N = 0.035 x TFA – 0.000038 x TFA^2, if TFA <= 420 or N = 8.0, if TFA > 420 and V = Volume of HW tank.

SAP calculations:- the fuel costs for the communal space and water heating system (in £/year) were computed as follows:-

(SAP89) Space heating, CHP = 0 (assuming no CHP)
(SAP90) Space heating, boilers = SAP87 x fuel price (Table 12).
(SAP91) Water heated by CHP = 0 (assuming no CHP)
(SAP92) Water heated communally = (SAP51 x SAP84) x fuel price x SAP85.

(SAP93) On-peak percentage = determined as above (from Table 13).
(SAP93a) Off-peak percentage = 100 – SAP93.
(SAP94) On-peak costs = SAP51 x SAP93/100 x fuel price (from Table 12).
(SAP94a) Off-peak costs = SAP51 x SAP93a/100 x fuel price (from Table 12).
(SAP95) Heating pump costs = SAP88 x fuel price (from Table 12).
(SAP96) Additional standing charges = as determined above (from Table 12).
(SAP97) Total heating = SAP90+SAP92+SAP94+SAP94a+SAP95+SAP96.

Assumptions: The methodology included the following assumptions, that:-

- The communal heating system was not CHP. Whether the water was heated
- When associated with communal heating, immersion heaters used off-peak tariff, when available.

11. SAP RATING - ALL HEATING SYSTEMS

SAP (98-100): requires no further primary data.

Methodology: The Energy cost deflator for the 1998 version of the Standard Assessment Procedure (SAP) was obtained from the bottom of SAP Table 12, and the energy cost factor (ECF) then calculated as below. Finally, the SAP rating was determined from the energy cost factor using the algorithm for SAP Table 14: *Sap rating by energy cost factor,* namely:-

SAP rating = 115 – 100 x $\log_{10}$ (ECF).

SAP calculations:- For dwellings with both conventional and communal heating systems, the final SAP rating was computed for each dwelling in the WHCS sample, as follows:-

(SAP98) Energy cost deflator = 0.97 (from Table 12).
(SAP99) Energy cost factor (ECF) = ((SAP97 x SAP98) – 40.0) / SAP5.
(SAP100) SAP RATING = 115 – 100 x $\log_{10}$ SAP99.

Assumptions: No further assumptions required.

ANNEX A2: IMPUTING FLOOR AREAS FOR THE 1997/98 WHCS SAMPLE

INTRODUCTION

This supplementary Annex details the methodology for providing each individual sample dwelling in the 1997/98 WHCS with a total 'SAP related' floor area by imputing this data from the 1996 EHCS. The same or a very similar methodology is used for imputing other variables required by the WHCS SAP model from the EHCS, including room heights, fenestration ratios, ground floor fractions, wall insulation and hot water cylinder volumes. For these different variables, the values deviated to varying degrees within the common dwelling categories for the WHCS and EHCS that were developed for the imputing process. For total floor areas there was a limit on how tight the dwelling categories could be made, but for other variables such as room heights and fenestration ratios, where there is less variance generally, very tight groupings were achieved.

To calculate SAP ratings and fuel poverty requires the determination of the floor area of the dwelling in the manner specified by the Standard Assessment Procedure (SAP). As the Welsh House Condition Survey (WHCS) provides no direct data on dwelling dimensions, the relevant floor areas for each sample dwelling has to be imputed from the English House Condition Survey (EHCS). The SAP related floor area is available from the 1996 EHCS but is significantly different from the general floor area included in the EHCS key variables.

To impute the relevant floor areas, it is assumed that dwellings with the same physical characteristics, that have the same number of habitable rooms and/or bedrooms, have similar SAP related floor areas whether they are built in England or Wales. Consequently, the main stages in the methodology are:-

1) to determine the main variables, common to the WHCS and EHCS, that influence significantly the SAP related floor area;
2) to use these variables to construct for the WHCS and EHCS, comprehensive typologies of dwelling types, where similar floor areas can be expected;
3) to check, using the EHCS, that the distribution of the floor areas within each dwelling category is reasonably tight;
4. to modify the WHCS and EHCS typologies to improve the fit, as necessary;
5) for each final typology, to use the EHCS to calculate the mean SAP related floor area for each dwelling category; and
6) to assign these mean areas to the same dwelling categories in the WHCS.

The main variables influencing SAP related floor area

As the SAP related floor area is a continuous variable, multiple regression was used to indicate the common variables in the 1996 EHCS and WHCS which have the most influence on the value of this dependent variable. The standardised coefficients of the most important independent variables are shown in Table 1 for all dwellings and for each of the four main tenures. The order of importance of the variables is also shown.

As one would expect, the number of rooms in the dwelling appears to be the most important variable influencing the floor area. This is the case for all tenures, but the influence is noticeable less in the private sector, where the greater variation in room sizes and the provision or conversion to open plan living spaces results in a weaker relationship between room numbers and floor area. In the total stock, tenure also appears significant in determining the SAP related floor areas.

Table 1: Significant variables in determining SAP related floor areas for each tenure

Standardised coefficients (Beta)	All dwellings	Owner occupied	Private rented	Local authority	RSL
Number of rooms	0.362 [1]	0.345 [1]	0.281 [1]	0.438 [1]	0.466 [1]
Urban or rural	0.193 [2]	0.218 [2]	0.203 [2]	0.025 [7]	0.035 [5]
Internal stairs	0.089 [3]	0.072 [4]	0.076 [4]	0.361 [2]	0.110 [3]
Tenure	0.078 [4]				
Type of dwelling	0.072 [5]	0.061 [6]	0.173 [3]	0.029 [6]	0.198 [2]
Presence of attic	0.063 [6]	0.067 [5]	0.069 [5]	0.037 [4]	0.010 [7]
Basement present	0.059 [7]	0.074 [3]	0.055 [6]	0.056 [3]	0.019 [6]
Age of dwelling	0.015 [8]	0.014 [7]	0.048 [7]	0.031 [5]	0.046 [4]

Other variables also have a significant influence, but their order of influence tends to vary between the tenures. For example, whether the dwelling is in an urban or rural location appears a significant predictor of its size in the case of the private stock, but far less so in the case of socially rented housing, which has generally been built to more uniform space standards. Conversely, the presence of internal stairs appears more important in determining size in the public than in the private sectors.

The type of dwelling is more important to size in housing rented from private, housing association or registered social landlords than in the owner occupied and local authority stock. In the latter tenures, the presence of a basement has relatively more influence on floor area than in the other tenures. In the owner occupied stock, the age of the dwelling appears to have relatively little independent influence on determining the floor area, age being a significantly greater influence in rented housing, particularly in the privately rented and HA/RSL sectors.

Construction of dwelling typologies

As suggested by the results of the regression analysis, the typology for dwellings has been constructed using a combination of five different variables, depending on the tenure. These five variables are the:-

A) type of dwelling;
B) presence of internal stairs, attic and/or basement;
C) date of construction;
D) location of the dwelling, urban or rural; and
E) number of habitable rooms and/or bedrooms in the dwelling.

A) Dwelling types

Using only variables which are available from both the WHCS and EHCS, a new derived variable for basic dwelling types has been computed having 12 categories. In the main this variable uses the data on house types from the WHCS physical survey, but the assessment of whether the dwelling is a bungalow comes from the interview survey. Given the common understanding of the term 'bungalow', this should be reasonably reliable, but as with the EHCS classification of bungalows, this will include chalet bungalows, which have a small proportion of their floor space in attic rooms. Table 2 lists the 12 categories and gives the proportion of each type in each tenure in the Welsh housing stock.

Table 2: New derived WHCS variable for dwelling types and % of types in each tenure

Column percentages/number

	Type of dwelling	Owner occupied	LA/DBRW rented	Housing Associatn	Private rented	Total dwelling
1	High-rise purpose-built flats	0.0	1.2	0.2		0.2
2	Low-rise purpose-built flats	1.8	22.1	30.3	7.2	6.8
3	Converted flats	0.6	0.4	6.3	12.0	1.6
4	End-terraced bungalows	0.4	2.6	1.0	0.9	0.9
5	Mid-terraced bungalows	0.9	2.0	0.7	0.5	1.0
6	Semi-detached bungalows	3.9	5.2	1.4	2.2	3.9
7	Detached bungalows	9.2	0.3	0.8	3.6	6.9
8	Temporary dwellings	0.2			0.2	0.1
9	End-terraced houses	9.2	13.5	12.2	9.3	10.0
10	Mid-terraced houses	23.1	19.2	25.2	31.9	23.1
11	Semi-detached houses	30.9	32.3	20.7	13.8	29.6
12	Detached houses	20.0	1.4	1.2	18.4	15.9
	All types (numbers)	**828,364**	**207,414**	**40,625**	**80,877**	**1,157,280**

B) Presence of internal stairs, attic and/or basement

As well as the type of dwelling, the number of floors inside the dwelling also affects the floor area, as it changes the relative floor space needed for the circulation between rooms. Unlike the EHCS, however, the WHCS does not include a question on the number of floors in the actual dwelling, but like the EHCS does record whether the dwelling has internal stairs, an attic or a basement. These latter variables have been used to produce the following derived variable to further distinguish maisonettes from flats and single storey bungalows from chalet bungalows and houses with or without habitable attics and/or basements. Table 3 lists the 6 categories in this new derived variable and gives the proportion for the categories in each tenure.

Table 3: Proxy WHCS variable for number of dwelling floors and % of categories in each tenure

Column percentages/number

	Floors in dwelling	Owner Occupied	LA/DBRW rented	Housing associatn.	Private rented	Total dwelling
1	Flats/bungalows with no stairs	12.0	28.3	32.7	20.4	16.2
2	Flats/bungalows with internal stairs	4.9	5.4	8.0	6.3	5.2
3	Houses with no attic or basement	75.3	65.2	58.6	65.6	72.3
4	Houses with attic	6.6	1.1	0.6	5.4	5.3
5	Houses with basement	0.9	0.0	0.1	1.4	0.7
6	Houses with both attic & basement	0.3			0.9	0.3
	All types (numbers)	**828,364**	**207,414**	**40,625**	**80,877**	**1,157,280**

C) Date of construction

Other characteristics being equal, the age of a dwelling is a further significant factor in determining its size, particularly in the rented sectors. In the WHCS, the physical survey variable giving the age of a dwelling has just four categories as listed in Table 4 below. These are compatible with the categories used in the EHCS, although the latter uses a further three categories for pre 1919 housing and two categories for post 1964 housing.

Table 4: Existing WHCS variable for date of construction and % of ages in each tenure

	Age of dwelling	Owner Occupied	LA/DBRW rented	Housing associatn.	Private rented	Total dwelling
1	Pre 1919	12.0	28.3	32.7	20.4	16.2
2	1919 to 1944	4.9	5.4	8.0	6.3	5.2
3	1945 to 1964	75.3	65.2	58.6	65.6	72.3
4	Post 1964	6.6	1.1	0.6	5.4	5.3
	All ages (numbers)	**828,364**	**207,414**	**40,625**	**80,877**	**1,157,280**

D) Location

The regression analysis indicates that the location of the dwelling, urban or rural, may also influence its floor area, but that this influence is much stronger in the private than in the public sector stock. As shown in Table 5, moreover, rural housing makes up a substantially higher proportion of the private sector stock than of the public sector stock in Wales.

Table 5: Existing WHCS variable for location and % of categories in each tenure

	Location of dwelling	Owner occupied	LA/DBRW Rented	Housing associatn.	Private rented	Total dwelling
1	Urban	78.6	88.5	92.7	74.7	80.6
2	Rural	21.4	11.5	7.3	25.3	19.4
	All locations (numbers)	**828,364**	**207,414**	**40,625**	**80,877**	**1,157,280**

E) Number of rooms

As the regression analysis confirms, the number of bedrooms and other habitable rooms in a dwelling is the obvious pointer to its size. Both the WHCS and the EHCS record both the number of bedrooms and number of habitable rooms in a dwelling, although in the WHCS, the number of bedrooms is only recorded in the interview survey. Consequently, the final variable used to classify dwellings, in addition to those shown above is the number of habitable rooms and/or the number of bedrooms. The number of habitable rooms is banded into 9 categories, ranging from a few dwellings with just one habitable room to dwellings with nine habitable rooms or more. Table 6 gives the proportion of dwellings of each 'size' in each tenure in the Welsh housing stock.

Table 6: Existing WHCS variable for number of habitable rooms and % in each tenure

	Number of rooms in dwelling	Owner Occupied	LA/DBRW rented	Housing associatn	Private rented	Total dwelling
1	One habitable room only	0.1	0.6	3.1	0.7	0.3
2	Two habitable rooms	0.9	11.1	22.3	8.0	4.0
3	Three habitable rooms	8.2	21.1	25.6	19.0	11.9
4	Four habitable rooms	24.0	28.6	26.5	24.6	25.0
5	Five habitable rooms	32.4	30.3	16.2	21.7	30.7
6	Six habitable rooms	17.2	6.5	3.9	12.4	14.5
7	Seven habitable rooms	9.1	1.4	1.1	7.3	7.3
8	Eight habitable rooms	4.0	0.2	1.1	2.5	3.1
9	Nine or more habitable rooms	4.2	0.2	0.3	3.6	3.3
	All types (numbers)	**828,364**	**207,414**	**40,625**	**80,877**	**1,157,280**

The Local authority sector

In constructing the dwelling typology for the local authority stock, the type of dwelling, including the presence of internal stairs etc, the age of the dwelling and number of habitable rooms have been used.

In theory, combining the first three variables (A, B & C) produces 128 dwelling age/types, but in practice only just over half of these types (66) are present in the WHCS sample of local authority/DBRW dwellings. When further disaggregated by the number of habitable rooms, the typology for local authority dwellings comprises 210 categories in total. Inevitably, some of the dwelling categories have small

samples and this may reduce how representative their mean floor area is of the dwelling type nationally. However, by definition, these categories only represent a small proportion of the national stock and thus should not significantly affect the overall estimation and distribution of floor areas.

It is important, however, to ensure that, overall, the mean SAP related floor areas of the dwelling categories are reasonably representative and that, within each category, there are not large numbers of dwellings that have markedly different floor areas. Using the same dwelling typologies for the EHCS sample, the extent to which the floor areas vary within each category has been checked by examining their distribution and calculating their standard deviation.[10]

Distribution in sample of 9 LA categories

Taking just 9 of these dwelling categories, Table 7 shows the distribution of SAP related floor area around the mean for local authority semi-detached and mid-terraced dwellings built between the wars (which lack an attic and basement) by their number of habitable rooms. The Table also gives the EHCS and WHCS sample number and the grossed number of such dwellings in the English housing stock. From the 25% and 75% percentiles for the semi-detached houses, it can be seen that 50% of all these dwellings have floor areas within some 6% of the mean, while the 5% and 95% percentiles show that 90% of these dwellings have floor areas within some 18% of the mean. Similarly, the standard deviations of 10 or under also indicate that the distribution of floor areas in each dwelling type and size is relatively tight.

Table 7: Distribution of SAP related floor areas for 1919-44 local authority semi-detached and mid terraced houses, without attics or basements, by number of habitable rooms

Habitable Rooms	Sample sizes[1]	Grossed number	% of Type	Percentiles 5%	Percentiles 25%	Mean (not median)	Percentiles 75%	Percentiles 95%	Standard deviation
Semi-detached									
3	5/21	6,340	2.4	54	56	60.9	62	74	6.8
4	66/72	64,754	24.2	58	62	68.4	72	89	8.6
5	152/147	161,729	60.3	64	71	77.4	84	92	9.1
6	37/36	30,591	11.4	69	80	87.0	93	99	9.4
7	6/4	4,714	1.8	87	98	103.5	107	120	10.7
Mid terraced									
3	10/9	8324	6.4	54	56	61.2	66	68	5.0
4	55/32	44868	34.7	52	60	67.7	70	88	15.5
5	81/38	65995	51.0	62	69	76.5	83	94	10.5
6	9/9	9102	7.0	75	82	88.8	96	96	7.9

1 EHCS sample/WHCS sample

[10] The standard deviation is a common measure of the scatter or distribution of a set of measurements, equal to the square root of the mean value of the squares of all deviations from the mean.

The distribution of the SAP related floor areas in the four categories for mid-terraced housing is marginally less tight, but 50% of the dwellings still have floor areas within some 8% of the mean, while 90% of the dwellings fall within some 20% of the mean.

Distribution for total sample of LA dwellings

In Table 8, the standard deviations for each category (type, age and number of rooms) of dwelling are banded into four groups for all local authority housing. The Tables shows that as classified by type, age and rooms, over 76% of the dwelling categories, containing some 57% of all LA homes, have a standard deviation of under 10, while a further 17% of categories containing some 39% of homes have a standard deviation of between 10 and 15. Only some 7% of the categories containing just 4% of all council housing have a standard deviation of 15 or above.

Table 8: Standard deviations of SAP related floor areas for dwelling typology categories covering the total LA stock

Standard deviation	Number of categories	% of all Categories	Number of LA homes	Percentage of LA homes	Cumulative percentage
Under 5	104	46.6	265,987	8.0	8.0
5 to 9.9	66	29.6	1,638,616	49.1	57.1
10 to 14.9	37	16.6	1,297,119	38.9	96.0
15 or more	16	7.2	134,310	4.0	100.0
Total	**223**	**100.0**	**3,336,032**	**100.0**	**100.0**

Treatment of other sectors

The methodology adopted for the other sectors is essentially the same as for the local authority stock as described above. However, in the private sectors the dwelling typology needs to be further modified to achieve comparably tight dwelling categories.

As in the local authority stock, in housing rented from housing associations or registered social landlords (RSLs) the influence of the number of habitable rooms on the SAP related floor area is strong, while the influence of the location, urban or rural, is relatively weak. Consequently, the same dwelling typology as developed for the local authority stock has also been used on the HA/RSL stock. However, compared to the local authority stock, there are fewer dwelling types (33) in the WHCS sample of housing association dwellings and a smaller total number of dwelling categories (75), as appropriate to the smaller sample for this tenure.

Using the same LA and HA typologies without modification for the private rented stock produces a significantly larger overall variation in the SAP related floor areas within each dwelling category. However, the regression analysis indicates that whether private dwellings are in an urban or rural location has an influence on their floor area to a greater extent than for the public sector stocks. This is confirmed by the fact that further distinguishing private rented dwellings by their location, urban or rural, produces significantly less overall v ariation in the SAP related floor areas within the dwelling categories.

Adding location as a component of the typology obviously increases the number of dwelling types (from 65 to 101) and the total number of categories, after disaggregating by the numbers of rooms, from 226 to 289. However, aided by the disproportionately large size of the privately rented sector sample, this still provides adequate sample sizes for the dwelling categories containing the bulk of private rented housing.

As with private rented housing, the regression analysis suggests that whether owner occupied dwellings are in an urban or rural location has an influence on their floor area to a greater extent than for the public sector stocks. Because of this, the dwelling typology for owner occupied dwellings again uses the location (urban or rural) as well as classifying the data by dwelling type and age.

Initially, the dwelling typology was further disaggregated, as with the other three tenures, by the number of habitable rooms. However, an examination of the distribution of SAP related floor areas in each resulting category, shows that despite the use of the additional 'location' variable, the spread of floor areas in many of the dwelling categories remains significantly greater than in the case of the other three tenures, including the private rented stock.

This result is not altogether surprising. Others characteristics being equal, one would expect greater variation in the floor area of dwellings in the owner occupied sector than in the local authority stock. The regression analysis, in showing a weaker relationship between the floor area and number of habitable room, largely confirms this.

The distribution of the SAP related floor areas within each category can, however, be made significantly tighter by using a variable which combines the number of habitable rooms with the number of bedrooms. In practice, this produces 15 main categories of 'size', containing nearly 95% of the owner occupied stock. Overall, with this extended room categorisation as well as the consideration of location, the final typology for the owner occupied stock has over twice as many dwelling categories as any of the other typologies, but, in both the EHCS and WHCS, the sample of owner occupied dwellings is also easily the largest.

Assigning mean SAP related floor areas to WHCS sample

Having determined the dwelling typology for each tenure for both the WHCS and EHCS samples and, using the latter, checked that the distribution of SAP related floor areas is relatively tight in each dwelling category, the mean floor area is calculated for every individual category. For each of the four tenures, these means are then assigned to the same dwelling categories in the WHCS sample.

In each tenure, however, there are a significant number of Welsh dwelling categories that are not present in the English sample and for which, therefore, there are no SAP related floor areas. In these cases, the mean floor area for the nearest dwelling category is used, having reference to the variables in the dwelling typologies that have the least influence on dwelling 'size'. For example if, in the local authority stock, there is no EHCS sample of a certain dwelling type built post 1964, then the

mean for the same type built between 1945 and 1964 is used, dwelling age being a less important predictor of dwelling size in this sector.

While this may introduce further errors, the dwelling categories in the WHCS sample that are not represented in the EHCS are inevitably fairly uncommon types and, in total, account for only a small proportion of the housing stock in Wales. Similarly, the smaller the EHCS sample sizes of the dwelling category providing the mean for the SAP related floor areas, the less important that category is likely to be in the Welsh housing stock.

Using the above methodology, a SAP related floor area has been provided for each of the 12,037 sample addresses in the WHCS physical survey that represent the total of 1,157,280 occupied first homes in the Welsh housing stock.

ANNEX A3: CALCULATED U-VALUES USED IN 1997/98 WHCS SAP MODEL

Where not provided by the SAP standard tables, U-Values (in W/m^{2}K) were calculated by CSE using the NHER Builder software program for common materials and thickness, appropriate to date of construction where specified. Where samples of the type of construction were very small, some similar types were grouped and the U-value for the most common type used.

1: GROUND FLOORS	**U-Value (W/m^{2}K)**
Suspended timber ground floor, no insulation	1.99
Suspended timber ground floor, with 100mm insulation between joists	0.41
Suspended timber ground floor, with 150mm insulation between joists	0.29
Solid concrete floor, no insulation	2.43
Solid concrete floor, 50mm insulation below screed	0.60
Solid concrete floor, 75mm insulation below screed	0.34

2: WALLS	**U-Value (W/m^{2}K)**
Pre 1965 brick faced cavity wall, plastered, no cavity insulation	1.45
Post 1964 brick faced cavity wall, plastered, no cavity insulation	1.37
Stone faced, cavity wall, plastered, without no insulation	1.57
Pre 1965 rendered cavity wall, plastered, no cavity insulation	1.35
Post 1964 rendered cavity wall, plastered, no cavity insulation	1.22
Tiled, cavity wall, plastered, no cavity insulation	1.21
Pre 1965 brick faced cavity wall, plastered, with cavity insulation	0.54
Post 1964 brick faced cavity wall, plastered, with cavity insulation	0.42
Stone faced, cavity wall, plastered with cavity insulation	0.54
Pre 1965 rendered cavity wall, plastered, with cavity insulation	0.55
Post 1964 rendered faced cavity wall, plastered, with cavity insulation	0.42
Tiled, cavity wall, plastered with cavity insulation	0.55
Brick or stone faced single leaf wall, plastered, no insulation	2.59
Rendered, tiled or clad single leaf wall, plastered, no insulation	2.24
Brick or stone faced single leaf wall, with insulation	0.89
Rendered, tiled or clad single leaf wall, with insulation	0.57
Brick faced 9 inch solid brick wall, plastered, no insulation	1.99
Stone faced 9 inch solid stone wall, plastered, no insulation	2.59
Rendered, tiled or clad 9inch solid wall, plastered, no insulation	1.57
Brick faced 9 inch solid brick wall, with insulation	0.85
Stone faced 9 inch solid stone wall, with insulation	0.94
Rendered, 9inch solid wall, plastered, with insulation	0.76
Clad, 9inch solid wall, plastered, with insulation	0.57
Brick faced > 9 inch solid brick wall, plastered, no insulation	1.55
Stone faced > 9 inch solid stone wall, plastered, no insulation	2.21
Rendered, tiled or clad > 9inch solid wall, plastered, no insulation	1.21
Brick faced > 9 inch solid brick wall, with insulation	0.76
Stone faced > 9 inch solid stone wall, with insulation	0.94

Rendered, tiled or clad > 9inch solid wall, plastered, with insulation	0.67
Insitu no-fines concrete cavity wall, plastered, no insulation	1.89
Insitu no-fines concrete cavity wall, plastered, with insulation	0.57
Concrete faced pre-cast concrete wall, plasterboard, no insulation	2.31
Rendered, tiled or clad pre-cast concrete wall, plasterboard, no insulation	2.28
Concrete faced pre-cast concrete wall, plasterboard, with insulation	0.37
Rendered, tiled or clad pre-cast concrete wall, plasterboard, with insulation	0.33
Pre 1965 traditional timber frame, plastered, no insulation	1.57
Pre 1965 traditional timber frame, plastered, with insulation	0.57
Post 1964 brick or stone faced timber frame, plasterboard, with insulation	0.29
Pre 1965 rendered, tiled or clad timber frame, plasterboard, with insulation	0.27
Metal sheet, plasterboard lining, no insulation	1.33
Metal sheet, plasterboard , with insulation	0.30
Other wall structure with brick, stone or rendered finish, no insulation	1.22
Other wall structure with brick, stone or rendered finish, with insulation	0.42
Other wall structure with timber, tile or metal finish, no insulation	1.29
Other wall structure with timber, tile or metal finish, with insulation	0.30

3: ROOF	**U-Value (W/m^2**
Pitched with natural slates, no insulation	1.885
Pitched with natural slates, 50mm insulation between ceiling joists	0.571
Pitched with natural slates, 75mm insulation between ceiling joists	0.425
Pitched with natural slates, 100mm insulation between ceiling joists	0.339
Pitched with natural slates, 150mm insulation between ceiling joists	0.248
Pitched attic roof with natural slates, 100mm insulation between rafters	0.357
Pitched with manufactured slates, no insulation	1.890
Pitched with manufactured slates, 50mm insulation between ceiling joists	0.622
Pitched with manufactured slates, 75mm insulation between ceiling joists	0.453
Pitched with manufactured slates, 100mm insulation between ceiling joists	0.356
Pitched with manufactured slates, 150mm insulation between ceiling joists	0.258
Pitched attic roof with manufactured slates, 100mm insulation between rafters	0.461
Pitched with plain tiles, no insulation	1.852
Pitched with plain tiles, 50mm insulation between ceiling joists	0.569
Pitched with plain tiles, 75mm insulation between ceiling joists	0.426
Pitched with plain tiles, 100mm insulation between ceiling joists	0.339
Pitched with plain tiles, 150mm insulation between ceiling joists	0.244
Pitched attic roof with plain tiles, 100mm insulation between rafters	0.356
Pitched with single lap tiles, no insulation	1.890
Pitched with single lap tiles, 50mm insulation between ceiling joists	0.620
Pitched with single lap tiles, 75mm insulation between ceiling joists	0.426
Pitched with single lap tiles, 100mm insulation between ceiling joists	0.356
Pitched with single lap tiles, 150mm insulation between ceiling joists	0.258

Pitched attic roof with single lap tiles, 100mm insulation between rafters	0.368
Pitched with metal covering, no insulation	2.086
Pitched with metal covering, 100mm insulation between ceiling joists	0.345
Pitched with metal covering, 150mm insulation between ceiling joists	0.252
Pitched attic roof with metal covering, 100mm insulation between rafters	0.262
Mansard with single lap tiles, 75mm insulation between rafters	0.470
Mansard with single lap tiles, 100mm insulation between rafters	0.368
Mono pitch with single lap tiles, 100mm insulation between ceiling joists	0.368
Mono pitch with single lap tiles, 150mm insulation between rafters	0.352
Chalet with single lap tiles, 100mm insulation between ceiling joists	0.356
Chalet with single lap tiles, 100mm insulation between rafters	0.368
Pitched with felt covering, 100mm insulation between ceiling joists	0.427
Pitched attic roof with felt covering, 100mm insulation between rafters	0.353
Mono pitch with felt covering, 100mm insulation between ceiling joists	0.352
Mono pitch with felt covering, 100mm insulation between rafters	0.352
Flat roof with paving, 100mm insulation	0.339
Flat roof with paving, unknown insulation	0.357
Flat roof with felt covering, no insulation	2.217
Flat roof with felt covering, 100mm insulation	0.356
Flat roof with felt covering, 150mm insulation	0.257
Flat roof with felt covering, unknown insulation	0.357
Flat roof with metal covering, 100mm insulation	0.345
Flat roof with metal covering, 150mm insulation	0.262
Flat roof with concrete finish, 100mm insulation	0.356
Flat roof with concrete finish, 150mm insulation	0.258
Flat roof with asphalt finish, 100mm insulation	0.427
Flat roof with asphalt finish, 150mm insulation	0.257
Other roof with single lap tiles, 100mm insulation between ceiling joists	0.356
Other roof with single lap tiles, 100mm insulation between rafters	0.368
Other roof with felt covering, 100mm insulation between ceiling joists	0.427
Other roof with felt covering, 150mm insulation between ceiling joists	0.257

ANNEX B1:– IMPUTING INCOME FROM THE WHCS

This Annex explains how missing income information was imputed for the 1997/98 Welsh House Conditions Survey (WHCS).

Introduction

A fuel poor household is defined as one that cannot afford to keep adequately warm at reasonable cost. For the purposes of the *UK Fuel Poverty Strategy,* which the government launched in November 2001, a fuel poor household was defined as one which needs to spend more than 10% of its income on all fuel use, to heat the home to a satisfactory standard and for lighting, cooking and running domestic appliances (DEFRA & DTI, 2001).

In this context, income is defined as including Housing Benefit or Income Support for Mortgage Interest (ISMI) and fuel use is defined as total fuel uses for both heating and non-heating purposes. The definition of a 'satisfactory standard of heating' varies according to household type (DETR, 2000 – see Annex C).

The 10% fuel poverty income threshold has a long history. The 1988 Family Expenditure Survey (FES) showed that households in the lower three income deciles spent, on average, 10% of their income (not including Housing Benefit or ISMI as part of income) on fuel for all household uses (DEFRA & DTI, 2001). It was assumed that this could be taken as representing the maximum amount that low-income households could reasonably be expected to spend on fuel.

The current definition of fuel poverty is complex and has been developed over many years of research. Variations of this definition have been used in previous research and in different parts of the UK. The *1991 English House Conditions Survey* for example used different heating regimes and definitions of income (DoE, 1996). In Northern Ireland, the definition of fuel poverty covered the cost of heating only (Boardman and Fawcett, 2002).

Income definitions used in fuel poverty studies in Wales

The extent and depth of fuel poverty is dependent on the definitions used of both income and heating regime. An agreed definition of fuel poverty is essential so that the extent of the problem can be estimated and progress on tackling it can be monitored. The National Assembly for Wales and the *Ministerial Group on Fuel Poverty* considered the definition of fuel poverty in Wales and England, taking account of the results of the public consultation carried out for new HEES/WFT. As part of the consultation the following question was asked:

In calculating the household income, should housing costs met by Housing Benefit (or ISMI), but not paid by the household directly, be excluded from income? Or would it be better to include housing costs met by Housing Benefit or ISMI as part of income when calculating whether a household is fuel poor?

The consultation responses on this issue were mixed, with 40% abstaining; 34% feeling that housing costs met by Housing Benefit (or ISMI) should be included when calculating household incomes; 20% feeling the opposite and 6% suggesting that either approach was acceptable but that the percentage figure used to determine fuel poverty should reflect the latest figure from the Family Expenditure Survey.

It has now been agreed to use two definitions of fuel poverty in Wales and England (DEFRA & DTI, 2001):

i) **The 'full' income definition (used for target setting)**
A household is in fuel poverty if, in order to maintain a satisfactory heating regime and cover other normal fuel costs, it would be required to spend more than 10% of its income (including Housing Benefit or Income Support for Mortgage Interest (ISMI)) on all household fuel use.

ii) **The 'basic' income definition**
A household is in fuel poverty if, in order to maintain a satisfactory heating regime and cover other normal fuel costs , it would be required to spend more than 10% of its income (not including Housing Benefit or Income Support for Mortgage Interest) on all household fuel use.

This research has also used a third definition of fuel poverty, agreed with the Welsh Assembly Government, that is consistent with the UK Government's Households Below Average Income (HBAI) statistics. This presents (equivalised [11]) income analyses on two bases: Before Housing Costs (BHC) and After Housing Costs (AHC). Annex B3 gives further information on the HBAI series and the equivalisation process. For the purposes of this research, the new fuel poverty definition can be summarised as:

iii) **The 'residual equivalised' income definition**
A household is in fuel poverty if, in order to maintain a satisfactory heating regime and cover other normal fuel costs, it would be required to spend more than 10% of its income **net of all housing costs** on all household fuel use.

The definition is based on an income definition that follows the HBAI-AHC series. This has the advantage of being consistent with the official UK and EU definitions of poverty, ie, households below 60% of median income after housing costs. It therefore enables such questions as "what % of fuel poor households also live in poverty?" to be addressed.

A number of different agencies are now using this definition. For example, the Greater London Authority has adopted 'disposable' income after housing costs as its **preferred** definition of fuel poverty in the Mayor's Energy Strategy, as have a number of local authorities outside London (GLA, 2004).

[11] Equivalisation refers to the process by which the income of each household member is aggregated across the household and adjusted to reflect the composition of the household. It is intended to reflect the relative needs of households of varying size and composition.

In Scotland, the eradication of fuel poverty is now defined as a priority within the Housing (Scotland) Act 2001[12]. Under the Act, s.89 (5)(b), Local Authorities are obligated to produce a housing strategy which "*ensures, so far as reasonably practicable, that persons do not live in fuel poverty.*" The Scottish Executive has adopted the same definitions of income for the purposes of measuring fuel poverty as are used in Wales and England (ie, 'full' and 'basic' income). However, in reporting on fuel poverty for the Scottish Executive, Scottish Communities also calculate the number of households in fuel poverty on the basis of residual income after housing costs (Scottish Communities, 2004).

The purpose of this Annex is to show how income was estimated in the WHCS for each of the three income definitions. This involved an eight stage procedure.

Imputing income in the WHCS

The 1997/98 WHCS asked households a banded question on their gross household income and whether they were in receipt of Housing Benefit, Income Support and a range of other benefits. No question was asked specifically about ISMI. Table 1 shows the gross income results from the WHCS from the 1997 Interview Survey. Income was divided into seven bands and, unfortunately, in over 35% of cases, no information on income was obtained.

Table 1: Gross household income in WHCS

Income Band	Frequency	Percent	Valid Percent	Cumulative Percent
Up to £4000	106779	9.1	9.1	9.1
£4001 - £7000	176721	15.0	15.0	24.0
£7001 - £10000	109642	9.3	9.3	33.3
£10001 - £15000	105175	8.9	8.9	42.3
£15001 - £20000	87024	7.4	7.4	49.6
£20001 - £30000	89955	7.6	7.6	57.3
Above £30000	65824	5.6	5.6	62.9
Refused	245850	20.9	20.9	83.7
Don't know	170309	14.4	14.4	98.2
NA	21681	1.8	1.8	100.0
Total	1178960	100.0	100.0	

The first step of the imputation exercise, therefore, involved imputing the income band of those households which either 'refused' to answer this question or answered 'Don't Know'. To do this, WHCS data were used as well as data from the 1997/98 and 1998/99 Family Expenditure Surveys (FES) and Family Resources Surveys (FRS).

[12] www.scotland-legislation.hmso.gov.uk/legislation/scotland/acts2001/20010010.htm

Stage 1: Harmonising the datasets

This stage involved harmonising a sub-set of variables, common to all three surveys (ie, WHCS, FES and FRS), that could be used to predict (impute) missing income band information. This was a time consuming and complex process which resulted in the construction of 40 socio-demographic and economic variables (listed in Annex B2).

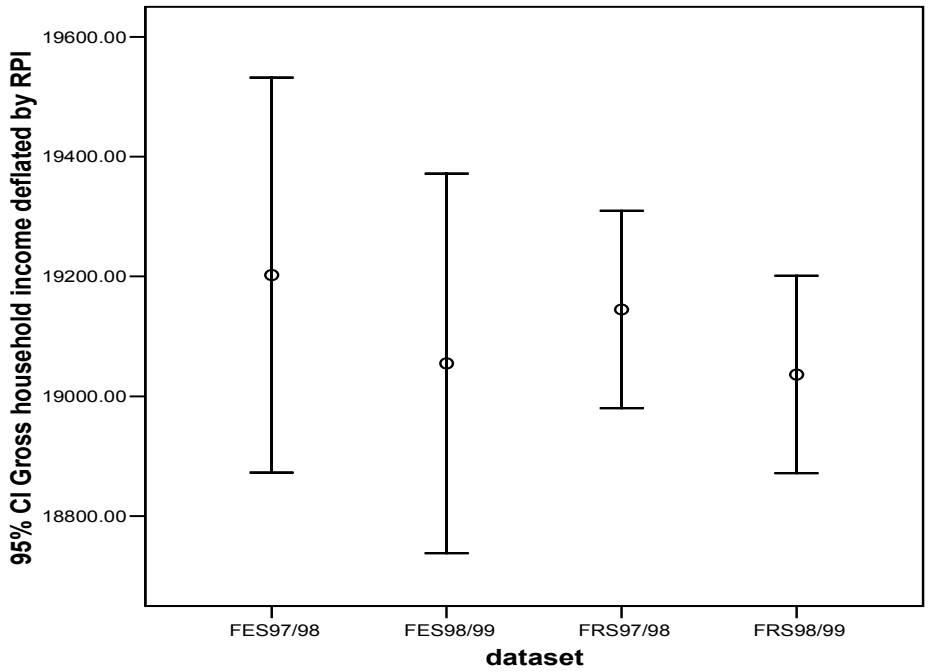
Stage 2: Deflating income

In order to obtain a sufficient sample size, two financial years of FES and FRS data were used in these analyses. It was therefore necessary to deflate gross and net income and the income bands to a common date. In the final fuel poverty analyses, income was deflated to September 1997 (mid way through the 1997/98 financial year using the Retail Price Index (RPI). The RPI for September 1997 was 159.3.

Figure 1 shows the result of this RPI deflation on the harmonised average gross household income as measured in the 1997/98 and 1998/99 FES and FRS data. The Error Bar Graph shows the mean (marked as a circle) and the 95% confidence interval of the mean (marked as a bar) for the four datasets after RPI deflation.

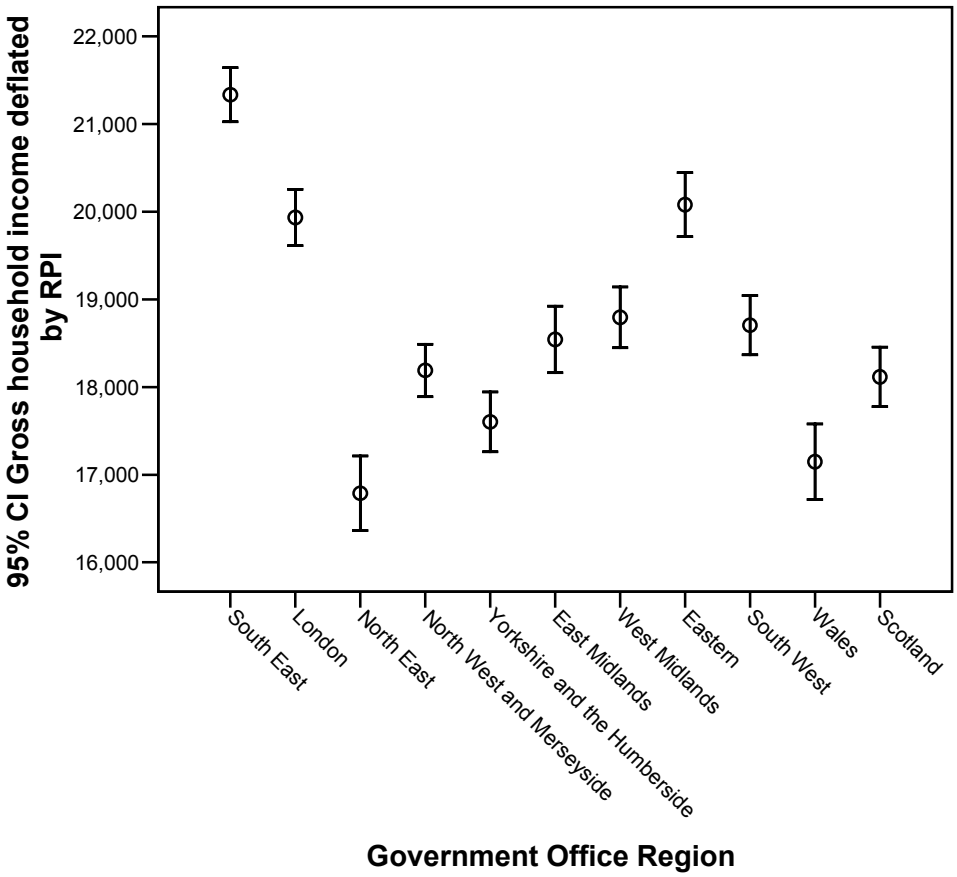
Figure 2 shows that households in Wales in 1997 had, on average, a lower gross household income than households in any other region of Britain - except the North East.

Figure 1: RPI deflated average gross household income



Cases weighted by Household Weight defalted to sample size

Figure 2: RPI deflated gross household income by region



Cases weighted by Household Weight defalted to sample size

Stage 3: Selecting the optimum sub-set of variables to predict income

Imputation is a time consuming process, even when using modern high speed computers, so it is necessary to select the best five predictor income variables. This optimum subset of variables was selected using Binary Regression Tree modelling (with income in bands as the dependent variable). The binary regression tree technique used was Exhaustive CHAID (Chi-squared Automatic Interaction Detection). CHAID is a method which uses chi-squared statistics to identify optimal splits. Exhaustive CHAID is a modification of CHAID that does a more thorough job of examining all possible splits for each predictor but takes longer to compute (Kass, 1980; Biggs *et al*, 1991). The target variable can be nominal, ordinal, or continuous. CHAID analysis allows both the combination of categories within variables and the sorting of variables to produce the most statistically significant results. CHAID also allows the identification of sub-groups with particularly high and low income bands (e.g. owner occupiers living in detached houses in full time professional jobs are likely to have a high gross household income).

The Exhaustive CHAID analyses produced two sub-sets of predictor variables of similar statistical power:

Set 1 (Impute 1) used number of workers (7 categories), number of rooms (8 cats), Economic Status (9 cats), Household type (5 cats) and Number of cars (3 cats), giving 7,560 cells in total.

Set 2 (Impute2) used number of workers (7 cats), number of rooms (8 cats), Economic Status (9 cats), Household type (5 Cats) and means tested benefit receipt (2 cats), producing 5,040 cells in total.

Stage 4: Hot Deck imputation of 'missing' gross income bands

The gross household income band of those WHCS households which either 'refused' to answer the income question or answered 'Don't Know' were imputed using the two optimal sub-sets of variables described above and the Hot Deck method. This procedure sorts respondents and non-respondents into a number of imputation classes according to a user-specified set of auxiliary variables (ie, Set 1 and Set 2 – see above). Missing values are then replaced with values taken from matching respondents (ie, respondents that are similar with respect to the auxiliary variables).

If there is more than one matching respondent for any particular non-respondent, then one matching respondent's value is selected at random. If a matching respondent does not exist in the initial imputation class, the class will be collapsed by one level, or until a match can be found. Hot-deck imputation assumes ignorable non-response. Hot-deck imputation has been used for many years by the Office for National Statistics (ONS) to impute missing data in the national Census.

Stage 5: Imputing gross household income in the WHCS

The optimum sub-set of variables to use for imputing gross income in the WHCS was selected using ANOVA modelling with gross income as a continuous dependent

variable. Unsurprisingly, the single best predictor of gross household income was the gross household income band. Other significant predictor variables were number of workers, number of rooms, number of cars, household type, receipt of means tested benefit and receipt of a retirement pension. The Hot-deck method was used to impute the gross household income for each household in the WHCS sample.

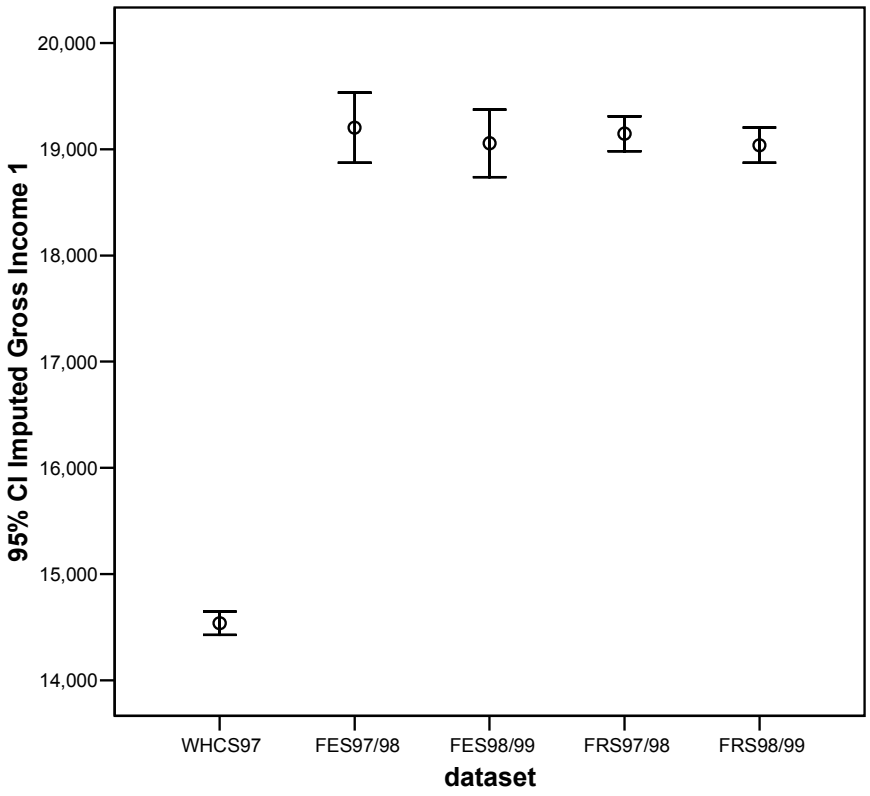
Stage 6: Imputing net household income in the WHCS

Linear Regression analysis showed that there was, unsurprisingly, a very strong relationship between Gross and Net household income – R squared of 0.971 before removal of income outliers and R squared of 0.978 after the removal of income outliers. Net household income was therefore imputed in the WHCS using just the imputed gross household income estimates using the Predicted Means imputation method. In this method, imputed values are predicted using an ordinary least-squares multiple regression algorithm to impute the most likely value when the variable to be imputed is continuous or ordinal.

Stage 7: Re-weighting the WHCS to allow for income non-response

The imputed gross and net household incomes for the WHCS data produced significantly lower average incomes for Wales than expected compared with the FRS and FES data. Figure 3 clearly shows the much lower WHCS gross household income estimates compared with the measured Welsh income data in the FES and FRS.

Figure 3: Imputed gross household income compared with measured gross household income in Wales



Cases weighted by Household Weight defalted to sample size

These large and significant differences are not a result of an error in the imputation but due to either under-reporting of gross income in the WHCS by band and/or non-response from 'richer' households in Wales to the income question.

Table 2: Banded gross household income in Wales: WHCS compared with FES & FRS

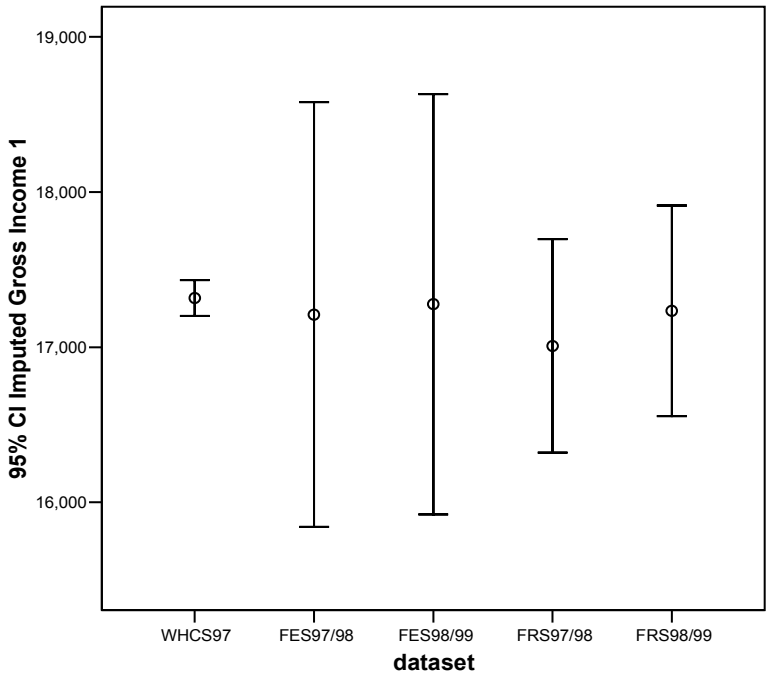
	Data set	
Gross Income Band	WHCS 1997	FRS & FES 97 to 99
Up to £4000	11.6%	5.0%
£4001 - £7000	21.2%	15.4%
£7001 - £10000	15.1%	16.5%
£10001 - £15000	15.4%	17.5%
£15001 - £20000	12.3%	11.3%
£20001 - £30000	13.6%	18.9%
Above £30000	10.8%	15.3%
Total	100.0%	100.0%

Table 2 shows that, in the WHCS, 11.6% of households were estimated to have gross household incomes in the lowest band (up to £4,000), compared with just 5% in this income band in the combined FES and FRS sample for Wales. However, in the WHCS, only 10.8% of households were in the over £30,000 band compared with 15.3% in the combined FES and FRS sample.

Re-weighting of 1997/98 WHCS sample

To overcome this problem, new weights were calculated to gross up the WHCS income bands so that they more closely reflected the gross household income band distribution in the combined FES and FRS data for Wales. Figure 4 shows the gross average household income in Wales by dataset after the application of these new weights and removal of the very 'rich' income outliers from the data. The WHCS average income is now similar to that in the FES and FRS data in Wales.

Figure 4: Gross average household income in Wales by dataset after re-weighting for non-response and income under reporting



Cases weighted by Household non response and Income under reporting weight

The new weighting was subsequently used, in place of the original WHCS weighting for the combined physical and interview survey sample, for producing the fuel poverty estimates for Wales. The new weighting was fixed for tenure (combining LA and HA properties in the public sector) and household type. Nevertheless, as a consequence of this re-weighting some of the other control totals given in this fuel poverty report differ slightly from those given in the main report of the 1997/98 WHCS.

Stage 8: Imputing Housing Benefit in the WHCS

In order to impute net household income for the 'basic' income definition it was necessary to impute the value of Housing Benefit in the WHCS. The WHCS recorded which households were in receipt of housing benefit but not the amount they received. Regression analyses showed that there was a relationship between rent paid (which is recorded in the WHCS) and amount of Housing Benefit received. The predicted means method was used to impute the value of Housing Benefit, which was then deducted from the imputed net household income. It was not possible to impute the value of Income Support for Mortgage Interest (ISMI) in the WHCS as there was insufficient data. (As it is known that the number of households in receipt of ISMI in Wales is extremely small, this has a negligible effect on the results.)

A similar process was used to calculate 'all housing costs' in order to calculate net household income, net of all housing costs. This income figure was then adjusted for household size and composition (equivalised) to produce the 'residual equivalised' income definition.

Conclusion

Using the eight stage procedure outlined above, net household incomes were imputed for the WHCS, using the 'full', 'basic' and 'residual income' definitions. Due to the use of different options in the methodology described above, three broadly similar income values were imputed for each household, giving a total of nine income variables - three for each income definition. All of these nine variables were subsequently used to produce the fuel poverty estimates, as detailed in Annex C1 below.

ANNEX B2: HARMONISING THE INCOME DATA SETS
(Cross-walk of WHCS, FES and FRS for determining household income)

Tender Variables (measurement level)	WHCS (merged dataset)	FES 97/98 & 98/99 (relevant data table) **(98/99)**	FRS 97/98 & 98/99 (relevant data file)
INCOME (household level)			
Gross Household income ***(hhinc_i)**	**Not available**	**X(P344)** gross normal wkly hhld income (set3)	**HHINC** gross household income (househol.por)
Gross household income band ***(hhincb_i)**	**H83** gross household income band	Derived	Derived
net household income ***(netinc_1)**	**Not available**	**X(P389)** normal weekly disposable hhld income (set3)	sum the adult individual income amounts (**NINDINC**) and, from the CHILD table, add the sum of earnings (**CHEARNS**) and the remaining income (**CHRINC**). (adult.por & Child.por)
Household savings	**H84** total gross savings band	**Not available 97/98, 98/99**	**Not available 97/98, 98/99**
STATE BENEFITS RECEIVED (person level)			
Retirement pension **(retpens)**	**P16**	**X(B338)** –last amt (set47)	**BEN1Q4** –in recpt (adult.por)
Widow's pension **(widpens)**	**P17**	**X(B339)** Widow's benefit- last amt (set47)	**BEN1Q5** –in recpt (adult.por)
JSA **(jsaincb)**	**P18**	**A303** JSA - rec/not rec income -based (set51)	**BEN3Q1** –in recpt (adult.por)
Income support **(incsupp)**	**P19**	**A229** – rec/not rec (set51)	**BEN3Q2** –in recpt (adult.por)

Child benefit **(chldben)**	**P20**	**X(B337)** – last amt (set51)	**BEN1Q1** –in recpt (adult.por)
Family credit (FIS?) **(famcred)**	**P22** Family Credit	**A257** FIS – rec/not rec (set51)	**BEN3Q3** Family credit –in recpt (adult.por)
Incapacity benefit **(incapben)**	**P23**	**A227** – rec/not rec (set49)	**BEN3Q4** –in recpt (adult.por)
Statutory sick pay **(sickpay)**	**P24**	**A279** – rec/not rec (set49)	**BEN3Q5** –in recpt (adult.por), *Not Available 98/99*
Industrial Injury Disability Benefit **(iidb)**	**P25**	**X(B325)** – last amt (set47)	**BEN3Q6** –in recpt (adult.por)
HOUSING (household level)			
Council tax benefit **(ctaxben)**	**H80**	**X(B039P)** – amt of ben/rebate (set12)	**CTREB** –recvng any CT benefit/rebate (househol.por)
Housing benefit **(housbe_1)**	**H69** help with housing benefit	Computed based on amount of housing benefit received X(P204) (set 12)	**HBENEFIT** –whether qualify (renter.por)
Housing benefit amount **(hbenam_1)**	*Not available*	**X(P204)** - hsng ben for cert claimant (set 12)	**HBENAMT** – housing ben amt (renter.por)
Rent paid **(grosre_1)**	**H70** how much rent paid **H71** payment period	**X(P257)** - rent-gross (inc. rates if paid sep) (set12)	**HHRENT** gross hhld rent (househol.por)
Number of benefits ***(nbenef_2)**	Computing based on household benefits received	Computing based on household benefits received	Computing based on household benefits received

HOUSEHOLD TYPE (household level)			
Household type ***(hhtype_1)**	**H200** hhld type (5 types)	Derived based on number of adults, children and pensioners in hhld (set2)	Derived based on number of adults, children and pensioners in hhld (househol.por)
WORK/EMPLOYMENT (person level)			
Economic status ***(econstat)**	Derived based on employment-related variables	Derived based on employment-related variables (set1, set2, set41, ilo(viewilo, 98/99)	Derived by recoding **EMPSTATI** empl status-ILO definition (adult.por)
TENURE (household level)			
Tenure groups ***(tenure_1)**	**H93** tenure groups	Derived by recoding **A122** tenure type-harmonised (set12)	Derived by recoding **PTENTYPE** tenure type (househol.por)
OTHER BACKGROUND			
Head of household ***(hoh)**	**P4** (HoH=1)	**A002** relationship to HoH (HoH=0) (set41)	**HOH** whether HoH (value=1) (adult.por)
Age (HoH) ***(age)**	**P8** age uncoded	**A005** age (set41)	**AGE** age at last bday (adult.por)
Sex ***(sex)**	**P10**	**A004** sex (set41)	**SEX** sex of resp (adult.por)
Marital status ***(marstat)**	**P11** recoded	Derived by recoding **A006** marital status (set41)	Derived by recoding **MARITAL** adult-marital status (adult.por)
Number of persons ***(nperso_1)**	**H20** number people in hhld	**A049** number persons (set2)	**HHSIZE** number of people in house (househol.por)

Number of adults	**H95** number adults/non-dep children ***(*1,2,3 or more)***	Derived using number of persons (A049) and number of children <16 (A0421) (set2)	**TOTADULT** total adults (derived) (househol.por)
Number of children	**H96** number dependent children ***(*0,1,2,3 or more)***	**G019** number children (set2)	**TOTCHILD** total children (derived) (househol.por)
Number workers in HHLD ***(nwork_2)**	Derived using new **ECONSTAT (=1,2,3)** variable *(see above)*	Derived using new **ECONSTAT (=1,2,3)** variable *(see above)*	Derived using new **ECONSTAT (=1,2,3)** variable *(see above)*
Number of rooms ***(nroom_1)**	*H87* ***total number of rooms-uncoded***	**A114** rooms in accommodation-total (set1)	**ROOMS** total number of rooms (househol.por)
Socio-economic group	**Not available**	**A091** SEG –HoH (set8)	**SEG** socio-economic group (adult.por)
Social class	**Not available**	**A095** social class HoH (set8)	**SOCCLS** social class (adult.por)
Occupational class	**Not available**	**A096** occupational class of HoH (set8)	**SOC** standard occupational classification (adult.por)
Number of cars (vehicles) ***(numcar_1)**	**H82** number of vehicles (finalh.sav)	Derived by recoding **A124** cars and vans in hhld (set1)	Derived by recoding **VEHNUMB** number of vehicles in hhld (inc motorcycles/other) (household.por)
Area ***(region)**	**Not applicable**	Derived by recoding **GOR** government office region (set1)	**GVTREGN** government office region (househol.por)
Dataset ***(dataset)**	Derived using dataset number	Derived using dataset number	Derived using dataset number

Household serial number ***(serno)**	Computed based on **AH1**	Computed based on **CASENO**	Computed based on **SERNUM**
Household weight ***(housew_1)**	**AHWT** Household weight	**X(WEIGHT)** Household weight	**GROSS2** Household grossing factor

Note: * included in final harmonised and imputed dataset

ANNEX B3: THE HOUSEHOLD BELOW AVERAGE INCOME (HBAI) SERIES

The HBAI series is published annually and represents the UK Government's 'official' analysis of low income. The HBAI statistics concentrate on the lower part of the income distribution, but provide comparisons with the upper part where appropriate. Income in HBAI refers to disposable household income: that is income (from earnings, self-employment, benefits, occupational pensions, investments and other flows) after the deduction of income tax, National Insurance contributions, local government taxes and certain other deductions. Each person's income is aggregated across the household and adjusted to reflect the composition of the household. This process is known as equivalisation (see below) and reflects the relative needs of households of varying size and composition (Frosztega, 2000).

HBAI presents income analyses on two bases: Before Housing Costs (BHC) and After Housing Costs (AHC):

Income Before Housing Costs (BHC) includes the following main components:
- usual net earnings from employment;
- profit or loss from self-employment (losses are treated as a negative income);
- all Social Security benefits (including Housing Benefit, Social Fund, maternity, funeral and community care grants but excluding Social Fund loans) and Tax Credits;
- income from occupational and private pensions;
- investment income;
- maintenance payments, if a person receives them directly;
- income from educational grants and scholarships (including, for students, top up loans and parental contributions);
- the cash value of certain forms of income in kind (free school meals, free welfare milk, free school milk and free TV licence for those 75 and over).

Income is net of the following items:
- income tax payments;
- National Insurance contributions;
- domestic rates / council tax;
- contributions to occupational pension schemes (including all additional voluntary contributions (AVCs) to occupational pension schemes, and any contributions to personal pensions);
- all maintenance and child support payments, which are deducted from the income of the person making the payment;
- parental contributions to students living away from home.

Income After Housing Costs *(AHC)* is derived by deducting a measure of *housing costs* from the above income measure (DWP, 2003).

Housing costs include the following:
- rent (gross of housing benefit);
- water rates, community water charges and council water charges;
- mortgage interest payments (net of tax relief);
- structural insurance premiums (for owner occupiers);
- ground rent and service charges.

Equivalisation of income

Both international and UK standards are clear that when comparing incomes of households of different sizes (numbers of people), income should be equivalised – adjusted for household size and composition. For example, the final report of the United Nations Expert Group on Household Income Measurement (Canberra Group) recommended:

> "*that income should be adjusted to take account of household size, using equivalence scales.*"

Both the DWP and the European Union have now agreed that low income/poverty statistics should be equivalised using the Modified OECD Scale (Atkinson *et al*, 2002; DWP, 2003b).

It is sometimes argued that since fuel costs are adjusted by household size and composition (eg, equivalised), then income does not also need be equivalised. However there are problems with this argument. For example, it is clear that a single disabled person who has mobility disabilities has greater fuel costs (all things being equal they would need more heat) than a non-disabled single person – and any fuel cost calculation should be adjusted accordingly. However, a single disabled person also has greater necessary health related expenditures than a non-disabled person (they would need to replace their wheelchair, buy medicines, pay higher transport costs, pay for adaptations to their home, have greater wear and tear on carpets and cloths, etc) and therefore their incomes should be adjusted (equivalised) for these additional necessary health related costs as this income is not available for them to spend on fuel.

Similarly, a family of 4 with an annual income of £15,000 is 'poorer' than a single person with an annual income of £15,000. If both these families live in a 1930's semi-detached house, the heating and fuel costs of the family of four will be slightly greater than for the single person. However, some of the family of four's non-fuel costs will be relatively much greater, eg, food and clothing costs etc. These costs have greater elasticity than fuel costs. Equivalised incomes therefore take account of these additional costs.

ANNEX C1: THE 1997/98 WHCS FUEL POVERTY MODEL

INTRODUCTION

This Annex describes the methodology used for estimating the level of fuel poverty in Wales for each sample household included in both the 1997/98 WHCS interview and physical surveys. It focuses particularly on the procedures for determining the total fuel costs required to maintain satisfactory heating, lighting, cooking and the running of normal domestic appliances. The methodology is based on that adopted to determine the official estimates of fuel poverty in England, as published in the 1996 EHCS Energy Report and the UK Fuel Poverty Strategy (DETR, 2000 and DTI/DETR, 2001).

The WHCS fuel poverty model produces estimates for the financial year 1997/98. This annual period is chosen at it covers the bulk of both the WHCS interview fieldwork when the income data was collected (mid February to end July 1997, excluding the month before the election in early May) and the physical survey which collected the data on which the required fuel costs are largely based (January to March/April 1998).

As with the 1997/98 WHCS SAP Model, some of the key data required to replicate the English methodology is not directly available from the WHCS and has to be imputed from the 1996 EHCS (Moore, 2003). Where data is imputed, the paper lists the relevant EHCS variables (in italics) and the common EHCS and WHCS variables used in the imputing process, with references to the appropriate sections in the English or Welsh physical surveys (EPS or WPS), interview surveys (EIS or WIS) or EHCS Fuel Survey (EFS). Where data is computed directly from the WHCS, similar lists of variables are given. The paper then describes the computing/imputing procedure used and the main assumptions underlying the methodology.

The penultimate stages of the SAP model (specifically stage 97) calculates the standardised heating cost for each occupied first home in the 1997/98 WHCS physical survey. However, these heating costs are based on a single standard heating regime, standardised average fuel prices and ‘average’ climatic conditions for the UK. As in the English estimates of fuel poverty, these fuel costs require modification to take account of:-

- The use of more than one heating regime to reflect different household needs.
- Regional variation in unit fuel prices and standing charges.
- Real variation in fuel prices due to the different fuel tariffs of households.
- Regional climatic variation affecting required heating costs across the UK; and
- The additional fuel costs associated with cooking, lights and appliances.

The methodology for achieving each of these modifications is detailed in the sections below. The final section covers the production of the fuel poverty variables.

1. HEATING REGIMES FOR DIFFERENT HOUSEHOLDS

Approach: To provide thermal comfort and safeguard health, all rooms that are likely to be frequently used, including the kitchen, bathroom and circulation space, need to be heated in winter while any occupant is at home. The standard heating regime used in the SAP model provides full-house heating, but for 9 hours only, typically split between morning and evening. This is considered inadequate for those households, particularly the elderly, who are likely to be at home most of the day. Conversely, full house heating to comfort standards is also considered uneconomic for households who are severely under occupying their home and have several unused bedrooms. However, as under-occupation occurs most commonly amongst retired households and sufficient borrowed heat is required in unheated rooms to prevent condensation and mould growth, all such dwellings are also assumed to require all-day (16 hour) heating.

To satisfy the above criteria, a composite satisfactory heating regime is employed. As shown in Table 1.1 below, this comprises three heating regimes - partial, full and standard heating - depending on the type of household, their employment status and the extent of under-occupancy of the dwelling.

Table 1.1: Definition of satisfactory heating used in English fuel poverty analyses

Weekday heating regime needed by:-	**Temp. of heated rooms**		**Extent of heating**	**Duration of heating**
	Living room	Other rooms		
All households in under-occupation	21° C	18° C	Partial	16 hours
Households likely to be at home all day	21° C	18° C	Full-house	16 hours
Households in work/ full-time education	21° C	18° C	Full-house	9 hours

In the definition of fuel poverty, a household is considered to be under-occupying their home only if their floor space per person is over twice that of the 1968 Parker Morris space standard and they have, at least, one more bedroom, if they are an adult household, and two or more extra bedrooms, if a household with children, than the Bedroom Standard[13]. Other households are considered likely to be at home

[13] This standard sets the minimum number of bedrooms for a household as:-
One for each cohabitating couple;
One for each man or woman aged 21 or over;
One for each two persons of the same sex aged 10-20;
One for any person aged 10-20 and a child under 10 of the same sex;
One for any person aged 10-20 and not paired as above;
One for each two of any remaining children under 10; and
One for any child remaining.

all day if they include children of pre-school age, any person aged 60 years or more or where the head of household or partner is otherwise not in full time employment. The remaining final category is for households where every member is in full-time employment or in full-time education.

a) Determining under-occupation

Variables for determining 'under-occupation': Those households who are under-occupying their home are computed by using the following WHCS variables:-

- Total floor area of dwelling (as imputed from 1996 EHCS)
- Number of people in household (WIS 1.1 – h20)
- The bedroom standard (WIS derived – h85)
- Age of youngest person in household (WIS derived)
- Age of oldest person in household (WIS derived)
- Type of family unit (WIS derived – fu4)
- Number of family units (WIS derived - h94)
- Number of adults and non-dependent children (WIS derived – h95)
- Number of dependent children in household (WIS derived – h96)

Methodology: Firstly, the last six WHCS variables in the above list are used to replicate the key EHCS variable of household type used in the determination of the 1996 English fuel poverty estimates. This involved the use of some person based variables, which are aggregated to household level for matching to the existing household variables. The new variable provides the seven household categories specified below:-

- **Younger couples with no dependent children**: includes married and cohabitating couples under 60 years with no children.
- **Older couples with no dependent children:** as above but with one or more of the adults aged 60 years or over.
- **Married couple with dependent children:** includes married and co-habiting couples with dependent children.
- **Lone parent with dependent children**: includes 1 parent with dependent children.
- **Multi-adult household;** includes lone parents with non-dependent children and households containing more than one couple or lone parent family.
- **Lone person aged less than 60 years**; and
- **Lone person aged 60 years or more.**

The extent to which each sample dwelling exceeds or falls short of the Parker Morris standard is determined from the first two WHCS variables in the above bulleted list and the number of family units. For each number of occupants, calculations are based on the largest dwelling types specified in the space standard – excluding less common three storey houses – and assuming that storage space is internal, as shown in Table 1.2 below.

Table 1.2: Parker Morris standard used in 1997/98 WHCS & 1996 EHCS fuel cost models

Number of occupants	Area m^2	Typical house type	PM range m^2
1 person	33.0	Bungalow	32.5 – for flat – to 33.0
2 persons	48.5	Bungalow	47.5 to 48.5
3 persons	61.0	Bungalow	60.0 to 61.9
4 persons	79.0	Two-storey terraced house	70.5 to 79.0
5 persons	89.5	Two-storey terraced house	82.5 to 98.5
6 persons	97.0	Two-storey terraced house	90.0 to 102.5
7 or more persons	114.5	Two storey terraced house	111.5 to 118.5

All households with over twice the floor area of the Parker Morris standard (as specified in column 2 of Table 1.2) and having, at least, one more bedroom than the bedroom standard, if an adult household, and two or more extra bedrooms, if a household with dependant children, are computed and deemed to be under-occupying their dwelling.

b) Determining duration of heating required

Variables for assessing time spent in dwelling: Those households who are most likely to be at home all day during the week and those in work or in full time education are determined using the following WHCS variables:-

- Number of people of working age in household (WIS derived – h103)
- Number of people in household of working age in work (WIS derived – h104)
- Number of persons in full or part time education/training (WIS derived from p 37)
- Age of youngest person in household (WIS derived)
- Age of oldest person in household (WIS derived)

Methodology: The first three of the above WHCS variables are used to determine households including economically active persons who are not in work or in full time education. Again this involved the use and subsequent aggregation to household level of person based variables. The last two variables in the list are used to determine households with children of pre-school age and those containing persons aged 60 years or over who are also most likely to be at home all day. Those household where all members are in work or in-full time education, and thus most likely to be away from the home in the day, are also determined from the above five variables.

Finally, using the newly computed variables indicating under-occupation and the likely time spent in the dwelling, the key variable for allocating a particular heating regime to each household in the WHCS is computed, as specified below:-

1 **Partial heating**: for all households severely under-occupying their home.
2 **Standard heating:** for households in full-time work and/or education.
3 **Full heating**: for households likely to be at home all day.

2. FUEL PRICES

The cost of heating generated by the 1997/98 WHCS SAP Model is based on standardised unit fuel prices (£/GJ) for each type of fuel used. However, using these average UK prices in the WHCS Fuel Poverty Model would have the result of under-estimating fuel poverty in Wales. This is for two reasons:-

1) At the time of the 1997/98 WHCS, average fuel prices, specifically for electricity, were significantly higher in Wales than in the rest of the UK. (By comparison, average gas prices were much more uniform across the UK, British Gas still being the predominant supplier at that time.)
2) Lower income households tend to pay more for their fuel than average, because of their more frequent use of pre-payment meters and less common access to direct debit discounts etc.

To account for the first factor, the model uses the average regional fuel prices and standing charges for heating fuels for Wales and the South West as published by SALKENT (previously Sutherland Associates), supplemented by comparable electricity tariff data obtained from SWALEC. SALKENT fuel prices are published for May and October of each year, and although VAT on fuel was reduced from 8% to 5% in September 1997, the October 1997 prices have been used as the second half of 1997/98 includes most of the heating season and also, probably, the majority of the lighting and cooking fuel costs.

To accommodate the second factor, the average 'Welsh' fuel prices and standing charges obtained from SALKENT and SWALEC are modified to account for the particular circumstances of each household. With no information in the 1997/98 WHCS on the fuel tariffs of particular households, the extent to which fuel prices vary across different types of housing and household groups is imputed from data from the 1996 EHCS fuel survey.

The EHCS fuel survey was a follow-up to the main 1996 Interview Survey and was not completed until 1998. Consequently, the fuel prices provided by these EHCS data are more or less contemporary with the 1997 WHCS Interview Survey. At this time, it is unlikely that the actual distribution of gas and electricity prices between different household groups varied significantly between Wales and England, British Gas being the main gas supplier in both countries and several of the electricity companies, such as MANWEB, also serving large parts of Wales.

a) Mains gas and electricity

Variables for imputing gas and electricity prices: For each WHCS sample dwelling, the proportion by which the unit fuel price for gas or electricity is above or below the average price for the country is imputed from the 1996 EHCS, using the following EHCS and WHCS variables:-

- *Annual gas or electricity consumption (in GJ from EHCS fuel files)* [14]
- *Annual gas or electricity charge (from EHCS fuel files)*
- *Standing charges (from EHCS fuel tariff data)*
- Central heating fuel (E derived & WPS 3.24)
- Other fixed heating (E derived & WPS 3.34)
- Water heating system (E derived, WPS 3.24/3.35 & WIS 1.14)
- Tenure (E derived & WIS derived)
- Dwelling type (E derived & WPS.2.3 & WIS.B)
- Number of habitable rooms (E derived & WPS 3.1A)
- Household type (E derived & WIS derived – see above)

Methodology: Firstly, the unit price of gas and/or electricity, excluding the standing charge, is determined for each EHCS sample dwelling from the survey's fuel consumption and tariff data. Using the EHCS sample, regression analysis is then employed to determine, from a long list of potentially relevant variables, that the main EHCS/WHCS variables influencing the unit gas or electricity price are the extent or type of heating, the tenure, dwelling type, number of rooms and household type (size, employment/retirement status etc). In the case of gas, the number of gas-fired space and water heating appliances present is found to be a main predictor, while for electricity, the type of appliance (eg, storage heaters or other electric appliances) proves a more important influence.

With these variables, a comprehensive typology of dwelling/household 'types', where similar unit prices might be expected, is constructed for each fuel for both the EHCS and WHCS samples. For the EHCS sample, the standard deviation for the unit price for each category in the typology is checked to ensure that these are tightly distributed. For both gas and electricity, the mean unit fuel price for each dwelling category in the EHCS is then assigned to the same dwelling category in the WHCS. Finally, the proportion by which the unit gas and electricity price is above or below the average is computed for each dwelling.

Assumptions: The above methodology is based on the following main assumption, namely that:-

- Households in Wales and England of the same size and employment or retirement status, having the same extent or type of heating, tenure, dwelling type and number of habitable rooms, have the same relative unit gas and electricity prices, these variables being shown to be the main influences on such prices in the English housing stock.

[14] 1996 EHCS annual consumption data is given in kilowatt hours (kWh) but this is converted to Giga-joules per year (GJ/year) for the imputing.

b) Standing Charges

As with unit fuel prices, standing charges also vary according to the particular tariff and metering arrangements with, for example, SWALEC customers with prepayment meters on the standard domestic tariff paying an annual standing charge of £73.51 in 1997, compared to an annual charge of £42.89 for households paying by direct debit. Again because of the lack of information in the 1997/98 WHCS on fuel tariffs, the extent to which standing charges vary across different types of housing and household groups has also been imputed using data from the 1996 EHCS fuel survey.

The methodology adopted is similar to that, described above, for imputing the variation in unit fuel prices, the main predictors again being found to be the type of heating, the housing tenure, dwelling type, number of rooms and household type (size, employment or retirement status etc).

c) Non-metered fuels

Unlike mains gas and electricity where the unit price can be determined for each sample household in the 1996 EHCS, the EHCS only provides the standardised price (as used in the SAP model) for non-metered fuels. In practice, the unit price of those fuels normally bought in bulk, such as fuel oil, may also fluctuate depending on consumption and methods of payment. Consequently, the unit prices for bulk LPG, solid fuel and fuel oil where used to fire main central heating boilers, are assumed to vary between households in a similar way to that of mains gas. The average 1997 prices for these fuels, as obtained from the SALKENT data for Wales and the South West, are thus also modified, by imputing the variation for different household groups using the 1996 fuel survey data.

Other non-metered fuels, such as bottled gas and solid fuels, used only for non-central heating appliances, secondary heating or cooking, are assumed not to be purchased in bulk, but obtained by all households using such fuels at the average prices for Wales and the South West.

3. HEATING COSTS

Approach: Using the variables produced in the above two stages, heating costs for the three heating regimes (partial, full and standard heating) are generated by modifying and re-running the 1997/98 WHCS SAP model.

Methodology: Firstly, the standardised unit prices used in the SAP model are replaced with the average 1997/98 fuel prices for Wales as obtained from SALKENT and SWALEC. The fuel price factors imputed from the EHCS are then used to revise these averages, for each household in the WHCS sample. The SAP model is re-run, using these new prices, to generate more realistic fuel costs for the standard heating regime for each household.

For the standard heating regime, the annual cost of heating depends on the SAP rating and the total floor area of the dwelling and can be calculated using the top 2 algorithms in Table 3.1 below. The cost of heating the dwelling to the remaining two regimes, partial all-day heating and full-house all day heating, can be similarly calculated using the modified versions of the standard algorithms, as also shown in Table 3.1.

Table 3.1: Algorithms for annual heating cost of different heating regimes

Annual heating cost (£)	Cost = (Energy Cost Factor x Total Floor Area + 40) / 0.97	
Where Energy Cost Factor for	Full-house, part-day heating	ECF = $10^{(115 - SAP/100)}$
	Part-house, all-day heating	ECF = $10^{(121.2 - SAP/109)}$
	Full-house, all-day heating	ECF = $10^{(117.2 - SAP/96.7)}$

These algorithms are used to determine the factor by which each dwelling, if heated to the partial regime or the full heating regime, will cost less or more to heat than if heated to the standard regime. These factors are then applied to the realistic heating costs for the standard regime, to also provide each home with more realistic fuel costs for the partial and full heating regimes.

Depending on the type of household, their employment status and the extent of under-occupancy of the dwelling (as determined in Section 1 above), the particular costs for one of the three heating regimes is then applied to each home in the WHCS sample.

4. CLIMATIC VARIATION

Approach: Designed to measure the physical standard of energy efficiency, the SAP model takes no account of the regional climatic differences that, in practice, can increase the heat losses and make a dwelling in, say, Berwick upon Tweed more expensive to heat than an identical dwelling in, say, Brecon. To account for this a regional correction factor, based on degree-day data (from a BRE 'Monergy' Guide), is used to modify the heating costs produced by the SAP model. SAP assumes all dwellings to be located in the East Pennines area where the climate is close to the average for the UK.

Methodology: Each heating cost, excluding standing charges, is reduced by 5% to take account of the average regional climatic difference between Wales and the East Pennines area.

5. NON-HEATING FUEL COSTS

Approach: The standard SAP (BREDEM-9) algorithms and its derivatives only provide the fuel costs for space and water heating. To determine the additional fuel use required for cooking, lighting and the running of normal domestic appliances, the BREDEM-12 fuel use algorithms are used. Regardless of the actual fuel consumption of households, these algorithms assume 'average' energy usage for cooking, lights and appliances, dependant on the type of cooker, the number of occupants and the floor area of the dwelling.

a) Determination of cooker type

In the modelling of fuel poverty for the 1996 Energy Report, BRE assumed that a gas hob and electric oven were standard for all houses and flats. For a subsequent analysis of fuel poverty in London, however, this assumption was improved upon, by using EHCS data on the actual fuels used for the hob and oven in dwellings (Moore, 2002). As the fuel used for cooking can have a significant effect on fuel poverty estimates particularly at the local level (for example, underestimating the problem in London by over 3%), cooking fuels are imputed from the 1996 EHCS.

Variables for imputing cooking fuels: Cooking fuels are imputed from the EHCS using the following EHCS and WHCS variables:-

- *Cooking fuel/s, including whether duel fuel (EFS derived)*
- Whether mains gas and/or electricity supply (EFS derived & WPS 3.23)
- Central and other fixed heating fuel (EPS 5 & WPS 3.24)
- Water heating fuel (EPS 5 & WPS 3.25)
- Tenure (E derived and WIS derived)
- Dwelling type (E derived & WPS.2.3 & WIS.B)
- Date of construction (EPS 4 & WPS 2.5)
- Location, urban or rural (E derived & WPS 7)
- Employment status of household (WIS derived)

Methodology: Using the EHCS sample, regression analysis is used to determine from a long list of potentially relevant variables, the above common variables as the main EHCS/WHCS variables predicting the type of cookers used. With these variables, a typology is constructed for both the EHCS and WHCS samples. For the EHCS sample, the predominant cooker type for each category in the typology is determined and the frequencies checked to ensure that these are high. Finally, the same cooker types are assigned to the same typology categories in the WHCS.

Assumption: The above methodology is based on the following main assumption, namely that:-

- Households in Wales and England with the same employment status, having the same mains fuel supply, space and water heating system, tenure, dwelling type, date of construction and location (urban or rural) tend to have the same types of cooker, these variables being shown to be the strongest predictors of cooker type in England.

b) Calculation of Non-Heating Costs

Using the cooker types imputed from the EHCS, the energy requirements (GJ/year) of the cooker in each sample dwelling is determined using the BREDEM-12 algorithms shown in Table 5.1. For the relatively few cookers (well under 5%) using non-metered fuels, the majority of which use fuel oil and LPG, the energy requirement – but not the cost - is assumed to be similar to that for mains gas. The cooking cost is calculated by multiplying the energy requirement with the more realistic unit costs for each fuel as determined in stage 2 above.

Table 5.1: Calculation of standardised energy requirement for cooking

Type of cooker		Energy requirement (GJ/year)
	All gas cooker	Energy = 2.98 + 0.60*N
	All electric cooker	Energy = 1.70 + 0.34*N
	Gas hob and electric oven	Energy = 1.49 + 0.30*N Energy = 0.85 + 0.17*N
where	N = Number of occupants	

For lights and appliances, the three BREDEM_12 algorithms shown in Table 5.2 are used. The specific algorithm used depends on the size of the product of the total floor area and the number of occupants in the dwelling. As with cooking, the cost of running lights and appliances is calculated by multiplying the energy requirement with the more realistic unit costs for electricity as determined in Section 2 above.

Table 5.2: Calculation of standardised energy requirement for lights and appliances

Floor area x number of occupants		Energy requirement (GJ/year)
Small	TFA x N < 710	Energy = 2.32+0.0232*TFA*N
Medium	710 <= TFA x N < 2400	Energy = 9.74+0.0146*TFA*N-$2.78*10^{-6}*(TFA*N)^2$
Large	2400 <= TFA x N	Energy = 28.77
where	TFA = Total floor area, and	N = Number of occupants

c) Additional standing charges

Approach: The total costs generated by the SAP model, only include standing charges for the specific fuels used for space and/or water heating. For example, if space and water heating in a dwelling on the 'mains' is provided by off-peak

electrical appliances alone and all cooking is by gas, then standing charges for both gas and on-peak electricity will need to be added to the fuel costs.

Variables for computing cooking fuels: The fuel/s for which additional standing charges are required are determined from the following WHCS variables:-

- Standing charge for heating fuels (var. 96 from WHCS SAP model)
- Whether mains electricity supply (WPS 3.23)
- Cooking fuel/s (Imputed from EHCS – as above)

Methodology: For each sample dwelling, any fuels used for cooking, lights and appliances, which are not also being used for space and water heating, are determined from the above WHCS variables. For each household in the WHCS, the additional standing charges obtained from the SALKENT and SWALEC data, are then allowed for each of these fuels.

6. FUEL POVERTY VARIABLES

In the final stage, the heating costs for the heating regime most appropriate to the household, and the fuel costs for cooking, lighting and the running of domestic appliances, including all associated standing charges, are summed to provide the total required fuel cost for each household in the combined interview/physical sample of the 1997/98 WHCS.

Once the total fuel costs for each household has been determined, this is divided by each of the imputed household incomes for that particular household and the resulting fractions expressed as a percentage to give the level of fuel poverty.

As described in the income paper, three sets of imputed household incomes are produced for:-

1) Annual ‘full’ income, including housing benefit;
2) Annual ‘basic’ income, excluding housing benefit; and
3) Weekly equivalised ‘residual’ income, after housing costs.

For each of these three income definitions, three income estimates are imputed and for each estimate, the level of fuel poverty is computed. The resulting nine continuous fuel poverty variables each give the total required fuel cost expressed as a percentage of a different figure for the annual household income.

These nine continuous variables, 3 for each income definition, are then each banded to give three degrees of fuel poverty, as follows:-

1) Not in fuel poverty - fuel costs of 10% of income or less.
2) In moderate poverty - fuel costs over 10% and up to 20% of income.
3) Severe fuel poverty - fuel costs over 20% of income.

In addition, the three continuous variables for residual income are also banded using the new thresholds below, such that for these variables the average total numbers of households in fuel poverty and in severe fuel poverty are approximately the same as for respectively 10% and 20% of full income:-

1) Not in fuel poverty - fuel costs of 13% of income or less.
2) In moderate poverty - fuel costs over 13% and up to 31.5% of income.
3) Severe fuel poverty - fuel costs over 31.5% of income.

Due to the relatively small sample of households in extreme fuel poverty, however, the third and fourth categories are amalgamated in all twelve banded variables (9 using the traditional thresholds and 3 the new thresholds) when cross-tabulating fuel poverty with other housing and household variables.

Finally, for each of the income definitions and threshold ranges, a single set of fuel poverty estimates is produced by first separately analysing the WHCS data using each of the three fuel poverty variables derived for each definition and then calculating the average of the three results.

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