Rising Fuel Prices:

the challenge for affordable warmth in hard to heat homes

Summary Report

Winton Smith, Anson Wu & Jacky Pett
Association for the Conservation of Energy

eaga partnership charitable trust

INTRODUCTION

This report is one of a number of documents arising from the project "Rising Fuel Prices: the challenge for affordable warmth in hard to heat homes". The project was designed to identify the most cost-effective measures to install in hard to heat homes to remove the risk of fuel poverty under different (rising) fuel prices.

This report aims to give a fairly detailed description of the project without requiring the reader to wade through the necessary background arguments and research leading to the development of the model Fuel Prophet. This is recorded in the Project report, which is available on our website, and contains full references and abbreviations. However, the findings from the initial analysis of the model are repeated here in full.

The website is www.ukace.org/research/fuelprophet

Here you can download, read or use:

- Fuel Prophet
- User Guide (on-line or download)
- Summary Report (this)
- Research Report

You can also give feedback to the ACE research team, inform us of changes to key measures (including price and improved data on lifetimes, maintenance costs etc), and let us know of new technologies and your experience of them.

There will also be news of project developments as they occur.

Association for the Conservation of Energy
Westgate House
2a Prebend Street
London N1 8PT
Tel 020 7359 8000
Fax 020 7359 0863
research@ukace.org

SUMMARY REPORT

NEED FOR AND DEVELOPMENT OF THE FUEL PROPHET

In the summer of 2004, a number of economic and political developments, both globally and in the UK, coalesced around the issue of fuel prices. This situation gave rise to the question: how, in a climate where liberalised energy markets simply cannot provide stable fuel prices, can policy and project decisions related to tackling hard to heat homes and fuel poverty be made?

The primary purpose of the Rising Fuel Prices project is to inform UK fuel poverty strategists and enable social housing providers to plan affordable warmth strategies in the context of increasing fuel prices. Specifically, the aim is to equip housing providers and expert commentators with a publicly available tool, Fuel Prophet, that indicates treatments of hard to heat homes which are both cost-effective and eliminate fuel poverty, taking into account various, fluctuating fuel price conditions.

Rising Fuel Prices focuses on 'hard to heat' or 'hard to treat' homes for two main reasons. First, hard to heat homes are generally expensive to heat, making them an even bigger priority for tackling fuel poverty through improving energy efficiency. Second, they are expensive to treat and while improvements are often not regarded as cost-effective, this may change when faced with rising fuel prices. Despite previous work (Pett, 2002 and 2004) which raised awareness of the scale of this issue, policy makers have not addressed the problem that improving these homes to an appropriate standard will cost less money than demolishing and rebuilding them. At least 30% of UK housing can be classed as hard to heat, and this problem is intractable due to the very low rates of demolition currently taking place. Moreover, an increasingly large percentage of those in fuel poverty live in hard to heat homes, simply because the programmes to eliminate fuel poverty do not address their plight. In addition, housing providers have to make investments to improve their housing stocks to comply with other governmental requirements, such as the Decent Homes Standard. Hard to heat homes often form part of these stocks and the investment decisions might not favour houses facing particular problems in reaching a Decent Standard of thermal comfort.

Various elements of this problem have been tackled in work by others, focusing on either fuel price increases and scenarios, hard to heat homes, fuel poverty or energy modelling. This project is unique as it addresses all four elements. Rising Fuel Prices has produced a tool that takes account of changes in the cost-effectiveness of energy efficiency measures[1], indicating which are best suited to alleviating fuel poverty in hard to heat homes in times of fuel price uncertainty.

Defining cost-effectiveness of measures

One of the most difficult areas to establish was the precise meaning of 'cost-effectiveness' when applied to the selection of measures to address energy efficiency in dwellings. It is apparent that for Defra (and in programmes supported by EST), payback is sufficient, i.e. the number of years it takes to recover the cost of installation from the savings in fuel costs. For the EEC, the definition used is simple cost-effectiveness, i.e. the amount of money saved over the life of the measure compared with the cost of the measure. This can also be discounted, so that pounds saved in the future are worth less than pounds saved now. In business, the concept of net present value (NPV) is often used, which considers the value of savings, discounted at an appropriate rate, over the

[1] For the purposes of this project 'energy efficiency measures' include insulation, heating and micro-generation technologies which reduce fuel bills when installed. These are referred to as 'measures' in this report.

life of the measure. The mathematics of this is different from the simple cost-effectiveness method. As the principal audience for this research is housing associations, who may consider the houses as their assets, it was thought this might be appropriate, however there is a complication because savings do not accrue to the housing association but to the tenant. During the development of the project a number of other concerns arose, so that both payback and NPV approaches were deemed necessary.

It should be noted that the principal difference in outcome between these two approaches is the weaker cost-effectiveness of longer-life measures under the payback mechanism, and improved attractiveness under NPV calculations.

Broader issues such as the wider benefits of health improvement, urban regeneration, employment and economic renewal are not considered in the benefits of improving the energy efficiency of the dwellings or the reduction in fuel poverty. Only NPV, payback and the effect on reducing fuel poverty are addressed in this project.

Fuel Price scenarios

The initial approach to this problem was to consider a 'ready-reckoner' approach, i.e. to use a sliding scale of price increases so that users could set their own levels of increases or decreases. This was identified as both impractical and unrealistic, therefore a set of fuel price scenarios were developed for a thirty-year period (this being the maximum product lifetime amongst the measures considered), based on well-established fuel and economic scenarios. These incorporate the DTI forecasts for fuel prices in the early years.

The scenarios aim to help users select a view of the future that they consider to give plausible percentage changes in fuel prices. These changes have been calculated over a thirty-year period, as this is the maximum product lifetime amongst the measures modelled.

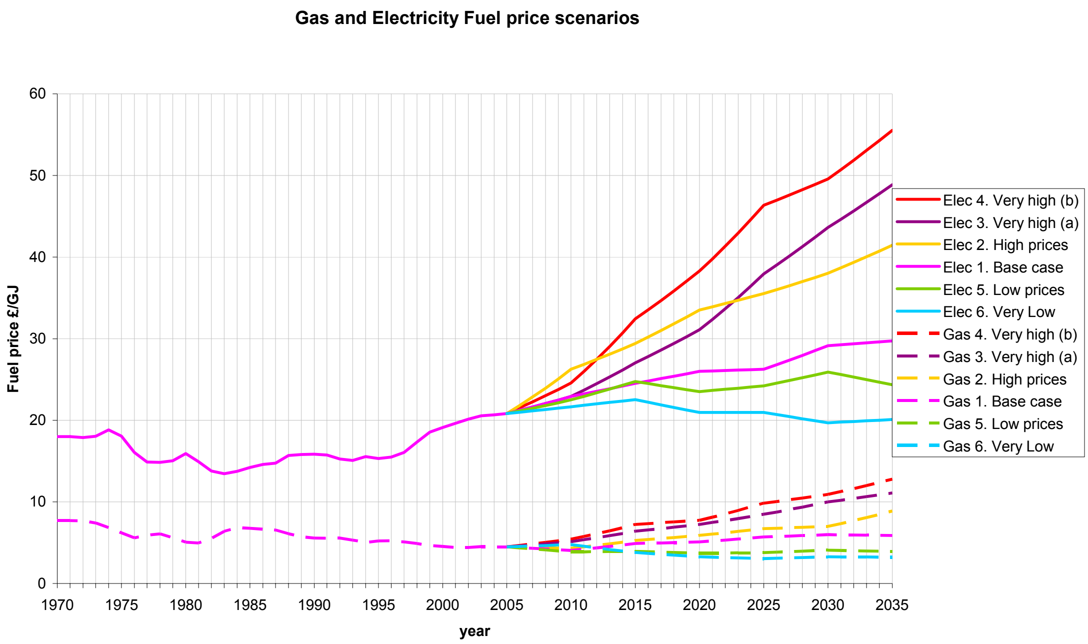


Figure 1: Gas and Electricity Price Scenarios

The trends of the scenarios for gas and electricity are shown in Figure 1, although coal and oil are also considered as fuels. Six fuel price scenarios are available:

1. base case – moderate increase in demand, rising prices
2. high prices – higher demand and prices than base case
3. very high prices (a) – fuel poverty eliminated
4. very high prices (b) – record levels of winter fuel poverty; summer mortality due to heat
5. low prices – similar price to base case in short term but access to cheap gas in longer term
6. very low prices – plentiful fuel and weak global markets; personal carbon allowances

These scenarios are integral to Fuel Prophet, as they are used to illustrate how the cost-effectiveness of potential measures, when added to different dwelling types, change in both relative and absolute terms over time.

Development of Fuel Prophet

The development of the model, called Fuel Prophet, covers four issues:

- Development of the base buildings
- Selection of appropriate measures and combinations of measures
- Development of the cost-effectiveness methodology and indicators
- Selection of fuel poverty and other indicators

The approach adopted was to limit the buildings modelled to a series of theoretical or 'base buildings' that satisfied our main objective: these were primarily hard to heat homes in social housing. Most social housing consists of low-rise flats, terraced houses and semi-detached houses, and these formed the foundation for our base buildings. Detached housing was added in order to complete the profile of major house types in the UK. Further variants were added; by wall type and by heating fuel. This produced a total of 17 base buildings as shown in Table 1; a manageable number from a modelling point of view, with a sufficient mix of specifications so that most hard to heat social housing could be simulated.

Table 1: Base Building Summary

Base Build	**Detached** (100m^2)	**Semi-detached** (85m^2)	**Terrace** (74m^2)	**Flat** (60m^2)
Wall / Heating type	Solid / gas Solid / electric Solid / coal Cavity / gas Cavity / electric	Solid / gas Solid / electric Solid / coal Cavity / gas Cavity / electric	Solid / gas Solid / electric Solid / coal Cavity / gas Cavity / electric	Solid / gas Solid / electric

Although the use of base buildings limits the outputs of the model to indicative values only, the *relative* merits of each measure or measure combination do not change when the building specification is slightly altered, even though the absolute values do.

Measures were selected by working through the logical cycle for saving on fuel costs: purchase fuel; use fuel for heat and power efficiently; prevent heat from escaping.

In order to make savings and improve energy efficiency, it is easiest to work back through this cycle. Preventing the heat from escaping can be one of the easiest solutions. This is achieved by stopping the warm air from leaking out (draught sealing), and by reducing the rate at which heat conducts through the walls, floors and roof (insulating). Insulating and draught sealing should be the primary method of saving. This is because they are virtually free from maintenance, lowers the amount of heat required, and maintains a more even house temperature. Insulation is the component least sensitive to future changes in climate, economics, and technology.

Newer technology is able to provide useful heat from fuel at higher efficiencies than older designs. Good examples of this are condensing gas boilers and electric heat pumps. Therefore, less fuel is needed per unit of heat output and, assuming the heat requirement does not increase, savings will be realised.

If the technology for a particular fuel is limited, switching to a different fuel source may be a solution. Primary fuels are also cheaper than a secondary source, i.e. electricity, so there can be savings by switching fuels even if there is no gain in efficiency. Micro-generation, including renewables, generate energy more cheaply than it can bought and although it does not reduce the amount of heat or energy needed, it can offset the cost of buying fuel.

Savings from using the various measures were calculated using Builder™, based on the BREDEM model. Solar, wind and CHP are not modelled in Builder™ and so assumptions were made based on information from manufacturers and trade associations

Measures to be modelled were selected according to three categories: building fabric including insulation measures to improve heat retention, heating systems to improve fuel efficiency, and micro-generation to reduce fuel. It was considered useful for the model to allow the application of these in any reasonable combination.

Table 2: Measures modelled, by type

Building fabric	Heating system	Renewable electricity
Loft insulation	Gas combi condensing boiler	Solar PV
Wall insulation: cavity	Ground source heat pump	Micro wind turbine
Wall insulation: internal	Air source heat pump	
Wall insulation: external	Oil condensing boiler	
Draught stripping	Wood pellet boiler	
Compact fluorescent lights	Solar hot water	
Double glazing	Micro CHP	
Primary pipe insulation		
Insulation package L		
Insulation package C		
Insulation package E		
Insulation package I		

Four insulation packages are shown in Table 2. These were introduced as there are measures that are cost-effective in the sense they are relatively inexpensive to install, but the effect on yearly energy bills is negligible when adopted in isolation. The packages each include loft insulation to 270 mm, draught sealing, and compact fluorescent lights fitted throughout the house, with variations adding wall insulation:

- INSL – Loft insulation only, no wall insulation
- INSC – Cavity wall insulation
- INSE – External wall insulation
- INSI – Internal wall insulation

U-values for relevant measures were either calculated by the Builder software, given the material construction, or were entered manually using values from the EST best practice guidelines. Data from the EST and other secondary sources were used to verify the calculations where possible.

The model simulates 21 measures or measure 'packages'. Decisions had to be made on treatment of various issues especially regarding prices, product specifications, maintenance costs and product lifetimes, all of which give rise to levels of uncertainty and the potential for changing assumed values as the markets change. The decisions adopted are visible in the model and can be amended by the user to take account of local robust data especially price considerations.

The wide range of grants and discounts available often depend entirely on the proposed project, making it impossible to estimate. The user can add their own grants and discounts or to adjust the installation costs to match their estimates more closely.

Indicators

Cost-effectiveness

Considerable problems arose in determining the precise treatment of 'cost-effectiveness'. The 'cost' considered arises from the initial installation cost and the ongoing maintenance cost of the product over its lifetime, whilst the 'effect' is to reduce fuel bills by saving energy and/or switching fuels. This fits well with social housing considerations, as the landlord bears the cost and the occupant receives the benefits. As the cost and benefit streams occur over time, both costs and effects were discounted, using the Treasury social rate of discounting, currently at 3.5%. The approach produces a single value, representing the sum of all costs paid by the housing provider and all savings to the tenant that result over the lifetime of the measure/s but represented in today's pounds. This is called end of life (EoL) net present value, and has been used as a key indicator. Also modelled (and graphed) is cumulative NPV, which illustrates how a measure's NPV changes over time (generally it improves, as most of the cost are incurred first, followed by savings/benefits that accrue over time).

Payback is a common measure of cost-effectiveness, used by Defra for assessing measures for energy efficiency programmes. It assesses how many years it takes for the value of energy saved to pay for the measures installed.

These three cost-effectiveness indicators are used: Payback, End of Life NPV and cumulative NPV.

Fuel Poverty

Beyond indicating the year one saving to tenants, it was decided to illustrate how these savings might change over time, in view of changing fuel prices, to evaluate a measure's ability to prevent fuel poverty. In England, the minimum income of a household is considered to be £5000 per annum if all benefits are taken. Theoretically, fuel poverty should be eradicated if the energy bill of all dwellings is £500 or less. Therefore, year on year saving to the occupier is graphed and can be compared to a fuel poverty line set to be 10% of the minimum income expected, currently £500.

In real terms, the £500 threshold should not alter but the fuel bill may, as a result of rising fuel prices. Discounting is not needed because the fuel bill can only be faced in that particular year and therefore there is no time preference or opportunity cost.

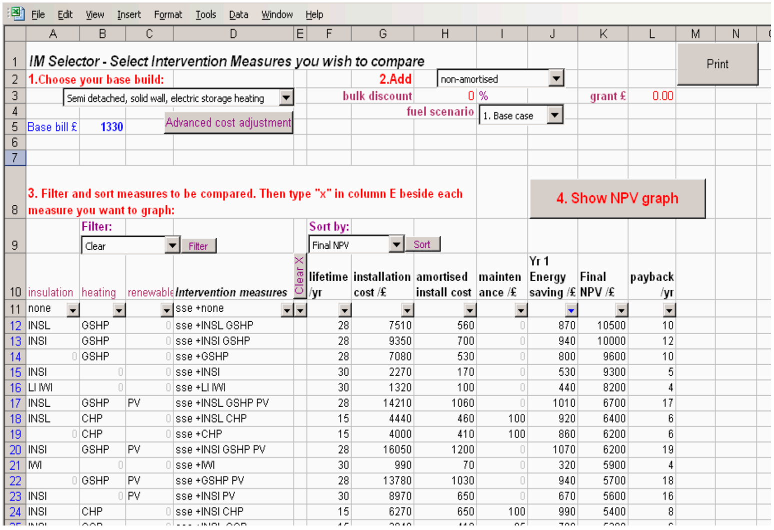
This is not a measure of cost-effectiveness but shows clearly the significance of the savings which can be hidden in cost-effectiveness calculations. If the model is to be used to identify measures to eliminate fuel poverty than the fuel poverty threshold is an important indicator.

The amount of fuel used by a household depends largely on the behaviour of the householders since every person has a different daily pattern and wants different levels of comfort. Although those in fuel poverty, especially the vulnerable fuel poor, may have need for higher heating regimes, the standard heating pattern, produced by the Builder software, was adopted. Consequently users will need to be mindful of the occupiers' heating patterns: measures added will produce greater savings in vulnerable homes and lower savings in under under-occupied homes than those indicated by the model.

The benefits of measures, beyond the effects they will have on fuel bills, have not been incorporated into the model, and there is much scope for further work linking these issues.

Use of Fuel Prophet

Figure 2: Main user screen for Fuel Prophet

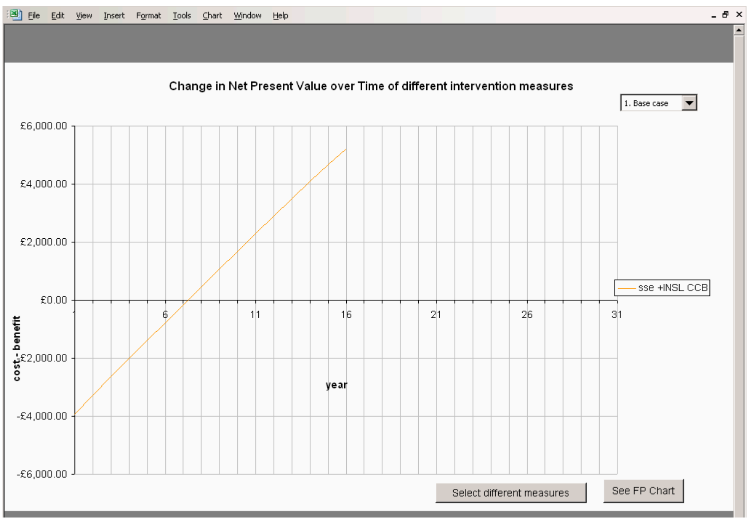


	insulation	heating	renewable	Intervention measures	lifetime /yr	installation cost /£	amortised install cost	maintenance /£	Yr 1 Energy saving /£	Final NPV /£	payback /yr
11	none			sse +none							
12	INSL	GSHP	0	sse +INSL GSHP	28	7510	560	0	870	10500	10
13	INSI	GSHP	0	sse +INSI GSHP	28	9350	700	0	940	10000	12
14	0	GSHP	0	sse +GSHP	28	7080	530	0	800	9600	10
15	INSI	0	0	sse +INSI	30	2270	170	0	530	9300	5
16	LI IWI	0	0	sse +LI IWI	30	1320	100	0	440	8200	4
17	INSL	GSHP	PV	sse +INSL GSHP PV	28	14210	1060	0	1010	6700	17
18	INSL	CHP	0	sse +INSL CHP	15	4440	460	100	920	6400	6
19	0	CHP	0	sse +CHP	15	4000	410	100	860	6200	6
20	INSI	GSHP	PV	sse +INSI GSHP PV	28	16050	1200	0	1070	6200	19
21	IWI	0	0	sse +IWI	30	990	70	0	320	5900	4
22	0	GSHP	PV	sse +GSHP PV	28	13780	1030	0	940	5700	18
23	INSI	0	PV	sse +INSI PV	30	8970	650	0	670	5600	16
24	INSI	CHP	0	sse +INSI CHP	15	6270	650	100	990	5400	8

The main controls in the model's interface are located on a single screen (see Figure 2) that allow the data to be manipulated and the results presented, whilst hiding and protecting the original data and calculations.

The user selects a base building of given house type, wall type and heating system which loads the energy consumption information for all the available installation measures and calculates the fuel bills, NPV etc. They then choose measures of interest: a list is displayed with abbreviated information; buttons and drop-down boxes allow the user to sort through the extensive list of measures quickly to select those of interest for analysis. Component parts can be analysed in detail and unsuitable measures can be eliminated. Analysing the measures is simplified by sorting them by the cost factor that the user considers to be the most important. Measures can then be compared on a graph.

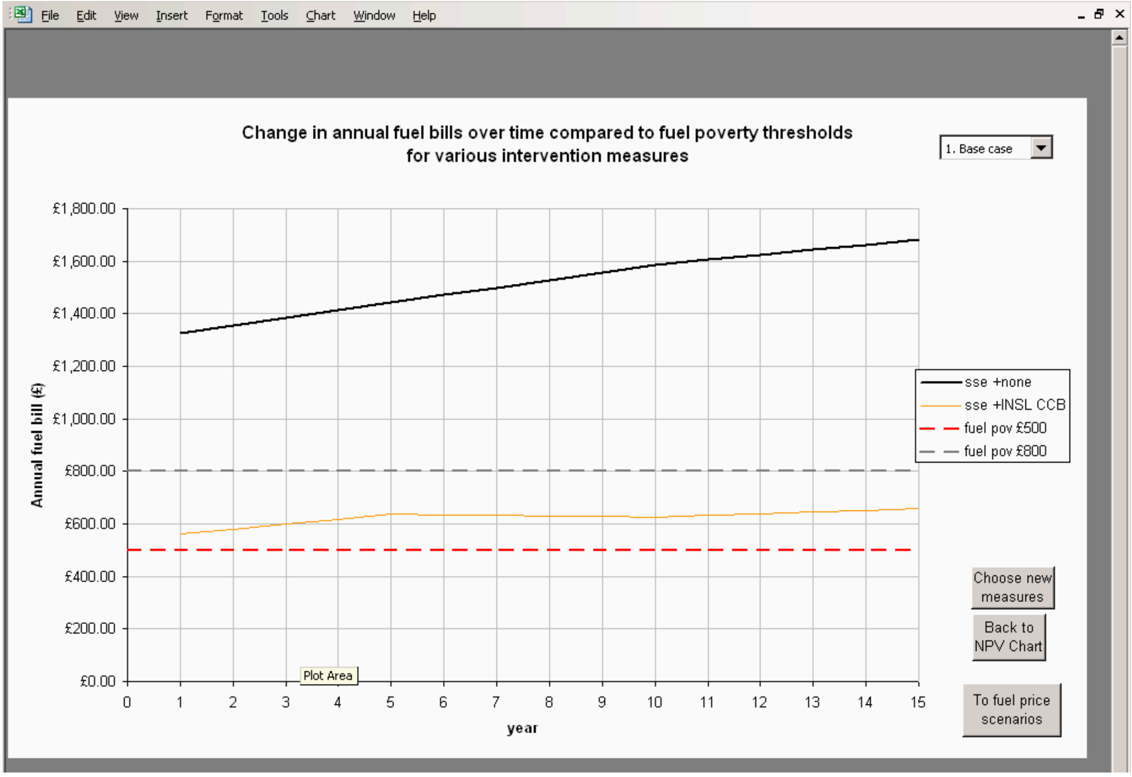
Figure 3: NPV graph for Insulation & combi boiler package for solid wall semi with electric storage at present, under base case fuel scenario.



The NPV graph shows how the costs and benefits of the measure change over time, when applied to a base building. The chart shown in Figure 3 shows the output for an insulation package with a gas condensing combi boiler in a previously electrically heated solid wall semi. It is possible to amortise the costs to reflect different funding options.

The Fuel Poverty graph (Figure 4) shows the annual fuel bill if the measures were installed, against the fuel poverty threshold £500 (red dotted line) and the bill in the base building (thick black line usually at the top). An additional £800 line is shown based on the fuel poverty definition using income excluding housing benefit and mortgage interest subsidy (Defra/DTI, 2001). The nearer the plot is to the bottom of the graph, the cheaper the fuel bill, and ideally the measure should fall below the £500 threshold to be sure the tenants will not be fuel poor.

Figure 4: Fuel Poverty chart for same measures combination as Figure 3



The combination of the two should enable an informed choice of possible options to be made which are both cost-effective and present significant savings to the household.

Selecting different fuel price scenarios, in either the main sheet or the box on the chart page will redraw the graphs and show how the various costs are affected.

User Guide

A user guide has been developed to enable housing association users in particular to apply the model. This is available on the project website as well as being designed into the instructions on the site itself.

PRELIMINARY FINDINGS USING THE FUEL PROPHET

The best measure to choose depends on its cost-effectiveness, the size of the saving needed, and its suitability to the particular situation. The ideal measure would be quick and easy to install, cost-effective, and achieve the required level of savings to the tenant, which are all dependent on the base building and the fuel price scenario.

The original concept for this research would have led to a simple table through which it was easy to see what types of measure are most effective in reducing fuel poverty given different fuel prices. Unfortunately, as shown in the report so far, the model is far more advanced and requires extensive testing to be confident that the first indications analysed below apply to all base buildings, under all fuel price scenarios and under all methods of indicating cost-effectiveness.

The model developed has created of the order of 100,000 possible combinations to analyse, which is clearly outside the scope of the project as it stands. Analysis presented here is therefore limited to general effects relating to house type, wall type and fuel type, then further comment is based on the semi-detached, solid wall, electric base building variant, unless otherwise explicitly stated.

House type

Between terraced, semi detached, and detached houses, given the same initial wall and heating type, and the same fuel price scenario, the cost-effectiveness of one measure relative to another does not change. This is because the difference in savings is reflected in the cost of installing the measure. For example, a terraced house will need less heat and save less heat, therefore a smaller and cheaper gas boiler is installed.

Within the same house type (e.g. terrace), with differing wall and/or heating, the cost-effectiveness of a particular measure will change because each base building has a different initial fuel bill. For example, loft insulation is more cost-effective in a semi detached house with electric storage heating (high fuel bill) compared to a semi detached house with gas central heating (lower bill).

A mid-level flat has very little exposed area which makes it naturally more efficient than houses. This results in lower cost-effectiveness for installing measures but also means it needs fewer improvements to bring the fuel bill below £500. It is also not appropriate to install a wide variety of measures such as loft insulation as the flats above and below buffer against heat loss (ceiling or floor insulation could be incorporated if necessary). A solid wall, on gas, mid-level flat should not be classed as hard to heat, because its fuel bill is below £500 and it has a SAP of 70.

Looking at payback times and final NPV, installing a measure in a more efficient house is less cost-effective. This implies that the priority for measures should be the least efficient (and probably, initially the more costly to improve) dwellings.

Wall type and insulation

Wall type has two implications within the model. Firstly it indicates the age of the building, as solid walls are generally older than cavity wall buildings. Secondly it creates an initial premise for the insulation provided by the unimproved dwelling (solid walls being of lower insulation value than cavity walls). Therefore wall type has a significant effect on the suitability of new building measures. Of all the insulation measures, wall insulation provides the largest savings, which in the case of cavity and internal wall insulation is also very cost-effective. The curves for these are shown in Figure 6. The external wall insulation package has the longest payback period and the lowest final NPV, as shown in Figure 5, although it has been costed at full price rather than at marginal cost. However, it also responds best to the fuel price scenario because it achieves the greatest savings. If the very high fuel price scenarios were realised, payback could be achieved in 15 years and the final NPV (after 30 years) is the same as that of the loft insulation package.

External wall insulation is also used as an additional measure when treating older walls to prevent rain penetration or dampness. The cost-benefit of this has not yet been modelled.

Solid walled houses often have minimal loft insulation; in this situation, loft insulation is the second most cost-effective measure with the second most significant savings. Topping up loft insulation from 100 mm to 270 mm has a much smaller effect because the improvement in U-value is far less and whilst it still has a positive NPV, the payback is much longer and the savings are small compared to wall measures. However it is considerably cheaper.

Due to the low cost, low maintenance, and long lifetimes of many of the smaller insulation measures, they show very short paybacks, good final NPV and should be considered in packages. Double glazing is the least effective insulation measure in the context of fuel poverty because it has very high installation costs and offers only low savings to the tenant.

The cost-effectiveness of the insulation packages fall into the following hierarchy (best to worst).

Insulation package with Internal wall insulation (INSI) (for solid wall dwellings)
Insulation package with Cavity wall insulation (INSC) (for cavity wall dwellings)
Insulation package with Loft insulation only (INSL) (both)
Insulation package with External wall insulation (INSE) (for solid wall dwellings)

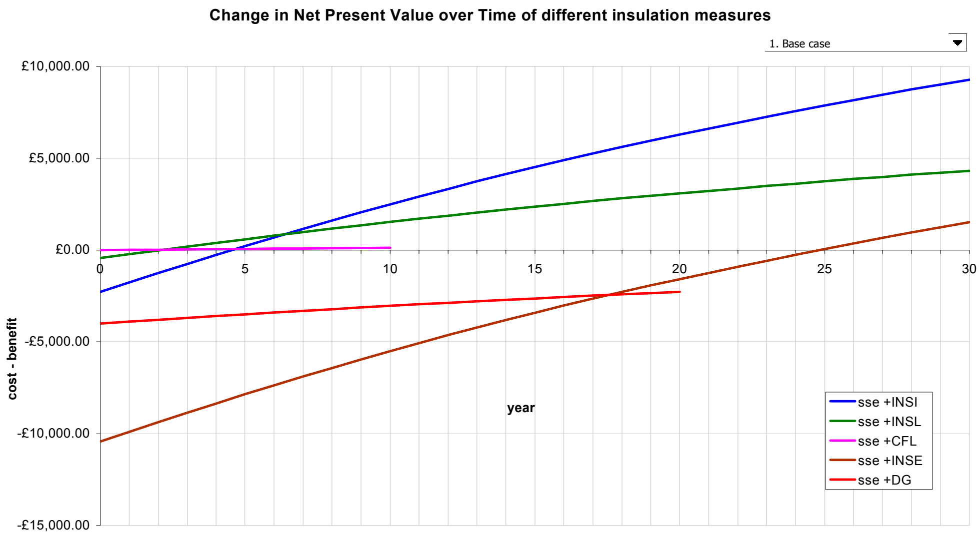


Figure 5: Comparison of insulation measures under base case fuel prices

All the insulation packages include the small, low cost-effective solutions, i.e. compact fluorescent lights, draught sealing, and loft insulation to 270 mm.

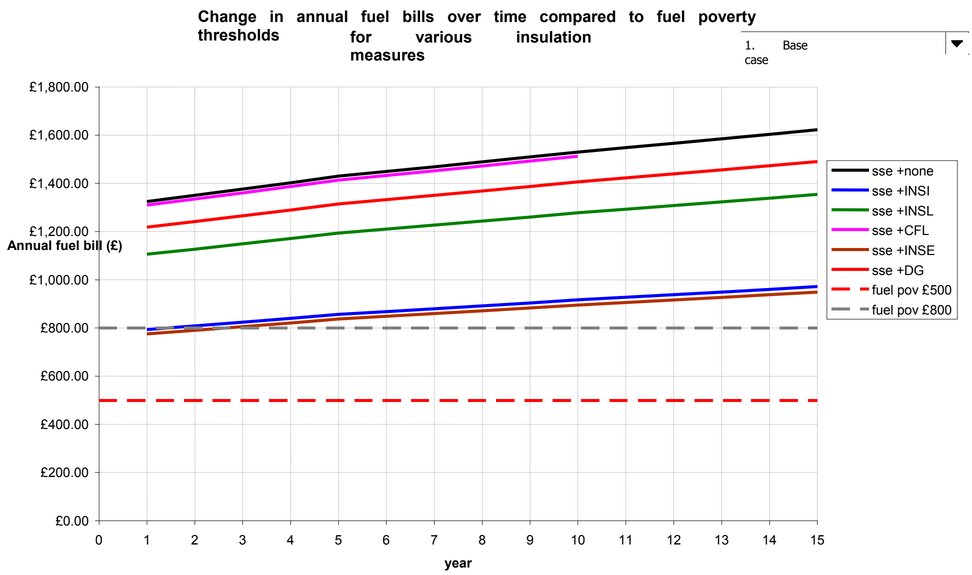


Figure 6: Fuel costs for insulation measures over time

This means that for a solid wall semi-detached house with electric heating, the insulation package with internal wall insulation is preferred, unless the condition of the walls means that refurbishment work is required anyway, in which case the cost of external wall insulation should be revised and the ranking reviewed.

Fuel type and heating system

Improving the efficiency of the heating system is the single most effective measure for reducing fuel bills, all other things being equal. This can be considerably more expensive than insulation, however, if the building is off the gas network and without a central heating system already. The heating system also dictates the fuel type and thus, for more difficult properties, more alternatives need to be considered.

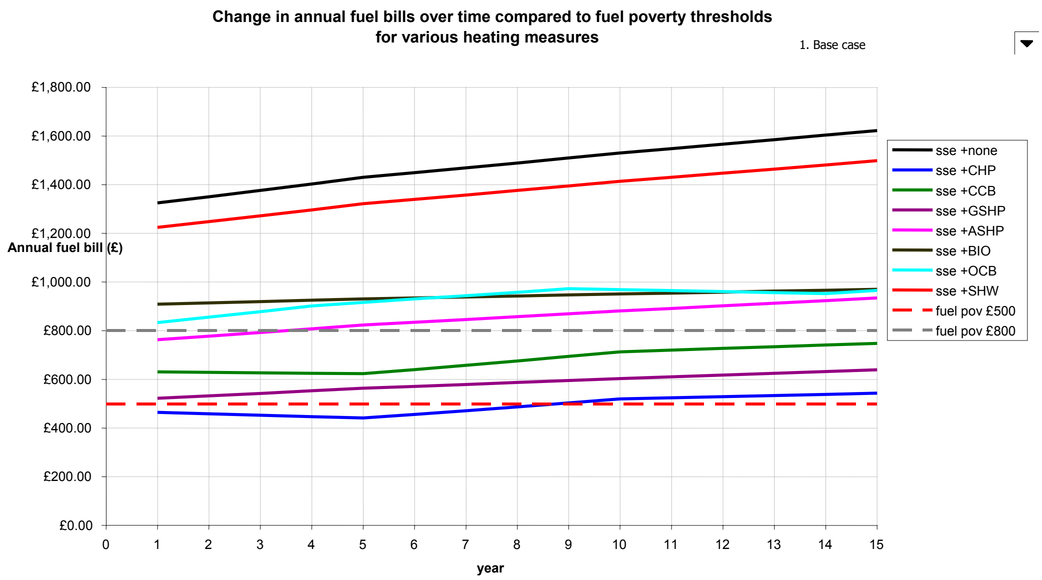


Figure 7: Reduction in fuel bills for different approaches to heating

If all fuel types are available, the most cost-effective solution based on the model and using currently available data is generally a micro-CHP unit followed by condensing combi-boiler, ground source heat pump (GSHP), air source heat pump, and biomass boiler (see Figure 7). *However, this will change under different fuel price scenarios.* An oil condensing boiler only pays back under high and very high (b) fuel price scenarios, however, it does not take a dwelling out of fuel poverty, even in combination with a full insulation package. This initial finding has significant implications for the new Warm Front grants.

Solar hot water does not pay back its installation costs and the savings are small.

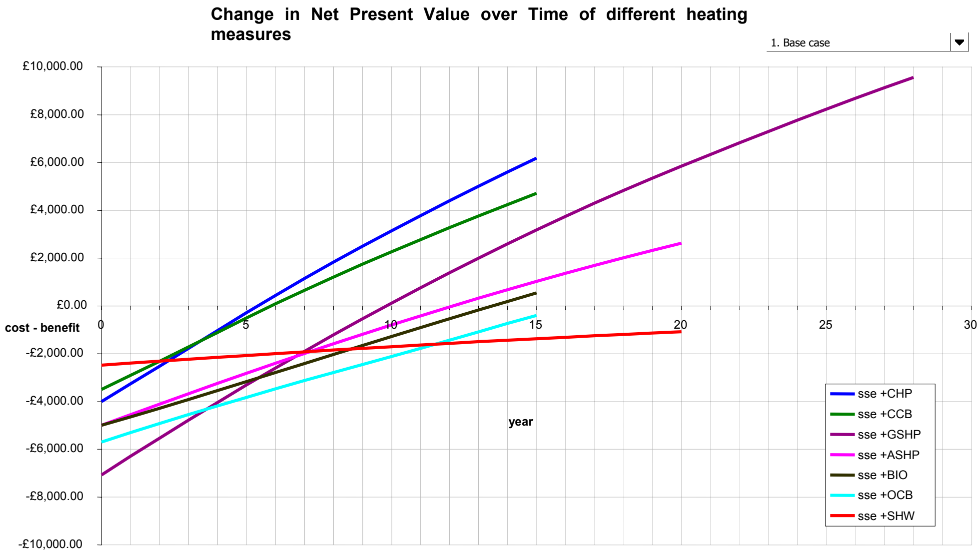


Figure 8: Cost-effectiveness measure (NPV) for heating measures

This ranking is due to the low price of domestic gas (1.6p/kWh) and the higher price of electricity (6p/kWh). Micro-CHP is best able to take advantage of this by consuming cheap gas to produce heat relatively efficiently and offsetting the electricity cost by producing electricity itself with the energy that might otherwise be wasted. It should be expected that new technology will produce the greatest savings; otherwise they would not be introduced to market.

The effective efficiency of heat pumps (COP 3-4) is able to offset the difference in energy price and under the fuel scenarios modelled there is no change in relative cost-effectiveness compared to the other heating measures. Furthermore, GSHP has very low maintenance costs[2] and a longer lifetime than the boilers, a significant saving to the tenant that offsets the very high capital costs, to produce the highest NPV of any single measure (Figure 8).

Off gas base buildings have been modelled without a heating distribution system (i.e. radiators etc) which creates a large additional cost for installing a central heating system needed for heat pumps and boilers. This factor pushes down the cost-effectiveness of heating systems but has no effect on the energy savings. However, the lifetime of the distribution system is much longer than the average 15 year lifetime of the boiler. It can be assumed that the added efficiency of a new distribution system will extend to any subsequent heating system and increase its cost-effectiveness but this cannot be demonstrated in the model.

[2] According to the heat pump manufacturers, no maintenance is required

Renewables

Photovoltaic panels (PV) and micro wind turbines (MWT) are the only two renewables considered since solar hot water is classed as a heating system. As currently modelled, the installation cost of PV is over 4 times higher than MWT (£6700 cf. £1500) but does not produce 4 times the electricity (1500 kWh cf. 1000 kWh). However, without significant financial assistance, neither option is cost-effective when applied in isolation (Figure 9). Energy production from wind, due to significant regional variations, has meant market claims range between 500 kWh – 4000 kWh annual energy production. Another factor which has not been modelled is the eligibility of renewables to receive Renewable Obligation Certificates (ROCs). Valued at £63 per 1000 kWh *of energy produced* this can produce a significant second income stream. All these variations suggest that the model outputs with regard to renewables may require further analysis.

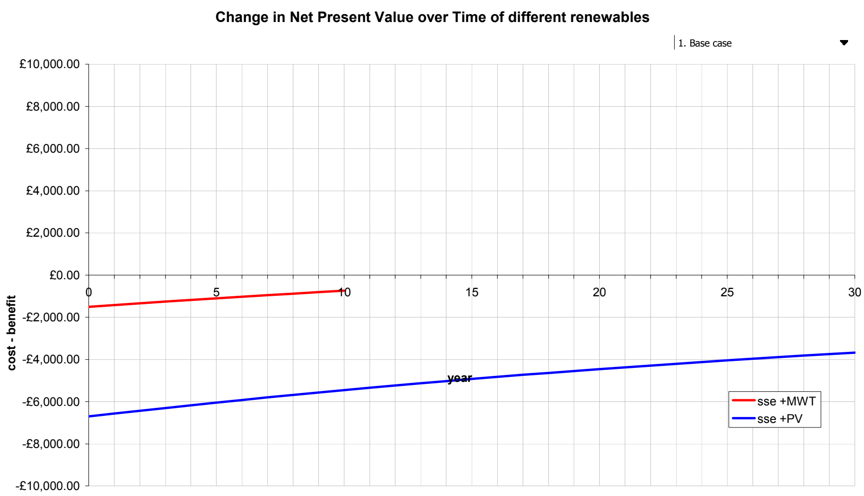


Figure 9: Change in NPV for renewables

Fuel Price Scenarios

The highest fuel bill increases will result from the highest fuel prices and the highest initial fuel bill. An untreated base building will therefore always show the biggest rise in fuel bill and high fuel prices makes every measure more cost-effective, particularly the measures providing the largest savings, such as external wall insulation and micro-CHP.

Under the highest fuel price scenario, to guarantee a household does not become fuel poor in the next 15 years the fuel bill must be reduced to around £300. This will offset the approximate 60% increase in fuel prices over the next 15 years. A pro rata adjustment could be made to the other high price scenarios. The standard package of wall insulation and combi condensing boiler does not achieve this – it will be necessary to install further measures within the next 10 years. For an off gas house, this target cannot be reached without using new technology and renewables.

Solid wall, open coal fire

Open coal fires are extremely inefficient; the base build energy consumption equivalent is £1600 for a terrace and £2100 for semi detached. Solid walls have very high U-values and lose a lot of heat. Large reductions in heat demand can be made through insulation and more efficient production of heat by switching fuel. The savings are therefore much higher than any other base build and measures are much more cost-effective. However, it is necessary to switch fuel types and therefore bear the install cost of a new heating distribution system.

Solid wall, electric storage heating

In a similar situation to open coal fire, the options available are the same: Base building energy bills are £1100 terraced and £1300 semi detached. New systems will require a new heating distribution system.

Solid wall, on gas

A house already connected to the gas network is assumed to have central heating. The amount of heat required can be substantially reduced by installing insulation and modest improvements to the heating efficiency can be made. Since a central heating system already exists, it is assumed there are no additional costs so a new boiler is still cost-effective.

Cavity wall, electric storage heating

Cavity wall houses have a better base U-value than solid wall which means less heat is needed to maintain a warm home. At the same time, cavity wall insulation has a higher U-value than other types of wall insulation (0.52). Savings are much lower as a result but they are more than offset by the very low price of installation compared with insulating walls internally or externally.

A lower initial heat requirement also means that the percentage improvement in heating translates into a smaller annual fuel bill saving. The consequence of this, given that the cost of installing a new heating system is the same as in a solid wall building, is to reduce its cost-effectiveness substantially. With the effects of discounting also considered, no heating measure which includes a central heating system will pay back in its 15 year lifetime. The only exception is a ground source heat pump which can function for 28 years and achieves payback only after 20 or more years, depending on the fuel price scenario.

Cavity wall, on gas

Not classed as a hard to treat home, this is the easiest base building to reduce energy costs below £500 a year in order to 'fuel poverty proof' the household. The simplest and most affordable action is to install a cavity wall insulation package and a condensing combi-boiler.

Initial results indicate that introducing cost-effective measures can lead to dramatic reductions in energy bills and therefore specific measures offer very considerable solutions for those in fuel poverty presently.

Changes in fuel prices *do* tend to alter the *relative* appeal of specific measures; (in terms of NPV and fuel savings) but successful integration will repel the effects of higher prices over time i.e. fuel bills are lower *and* more resistant to price fluctuations over time. This effect is a measure of 'fuel proofing' houses, reducing occupiers' exposure to high fuel prices.

Cost of Measures - Sensitivity Analysis

Changing the installation cost has an effect on a measure's cost-effectiveness. Increasing the cost of the installation will lower the final NPV and increase the payback period. The fuel savings, however, do not change. The extent to which the cost-effectiveness hierarchy is altered depends on the initial cost of the measure, the savings it creates and over what period these savings are made.

Future analysis

Further analysis will look at the ability of different measure mixes to maintain a Decent Home Standard over time, considered in view of the different pricing scenarios. There will also be a more detailed review of the insulation options and the effects of standard approaches across different house types, particularly in view of the comments relating to the cost-effectiveness of oil central heating (see page 13). The issues of integrating measures in order to resist the impacts of fuel price rises will also be explored in greater depth. Feedback is welcome from users of Fuel Prophet who have carried out their own analyses.

Key preliminary findings

The method used has indicated that, on the whole, fuel prices will have a significant impact upon the ability of different measures to improve the energy efficiency and, reduce the fuel costs in Hard to Heat and other homes. However there is one vital caveat: Despite their fuel savings being more heavily discounted, **insulation measures generally remain most cost effective, in terms of NPV, under all scenarios modelled: the choice of measure installed next, will depend on fuel prices**

1. Uncertainty is further removed as the hierarchy of measures (in NPV) remain quite stable, even when the costs of some measures relative to others change quite drastically (e.g. +/- 30%).
2. The major finding is that not only are remarkable savings in fuel bills achievable (over 50%) by installing cost-effective measures, but these bills remain much more resistant to fuel price fluctuations over time. This *'fuel proofing' can be seen as a key strategy* for alleviating fuel poverty during periods of rising fuel prices.
3. In certain situations, specific measures are likely to be more appropriate for removing people from the risk of fuel poverty than more cost-effective ones due to the amount of reduction in fuel used.
4. The long lifetime of many insulation measures (e.g. 30 years) means that their overall value is under-represented when combined with shorter-lived measures. This is relevant when considering wall insulation compared with shorter-term measures such as boilers (15 years). This may be a failure of the model but also reflects the current policy approach to decision making on payback versus whole life costing approaches.

CONCLUSIONS AND FUTURE MODEL DEVELOPMENT

The two specific target audiences for the project are social housing providers and fuel poverty/energy efficiency policy researchers. However during the course of the project a number of other users and more details of the key groups have been identified.

The potential users identified include:

1. Social housing providers: primarily asset managers, investment/procurement officers. In some smaller housing organisations this role might be undertaken by generalists also responsible for maintenance, and rent arrears officers or those responsible for programmes to improve tenant income may also find the outputs useful. It is furthermore likely that specialist consultants would be involved.
2. Fuel poverty, energy efficiency, renewables, social and private housing policy and programme designers (the model is of direct relevance to Warm Front, EEC, Clear Skies, Fuel Poverty Strategy and others)
3. Energy modellers and academics
4. Manufacturers and installers of the included measures
5. Agencies such as Sustainable Energy Centres, Citizens Advice Bureaus, Home Improvement Foundations
6. Building control and developers (New Part L requirements – to Assess LZC integration)

It would also be conceivable that private householders – i.e. the general public – could use the tool as a guide to measures for their own homes, but it would require some grounding in economic appraisal, and Fuel Prophet has not been designed for this potential audience.

From the list above, two groups of users emerge: the first group include those that have an interest in the model itself – the process by which outputs are calculated, the underlying data and assumptions used. This group would likely include most policy and programme designers, and possibly the manufacturers and trade associations with an interest in the measures modelled.

The second group include those that require outputs from the model, in order to inform investment decision-making. This group includes housing providers, public agencies developers and potentially the general public. The needs of *some* policy and programme designers might only reach this far also.

Fuel Prophet is currently in the form needed by the first group (the 'Policy Group') and is available to download as an Excel spreadsheet. The underlying assumptions, data sets and calculation functions are accessible, and some of these will be open to manipulation.

The needs of the housing group centre on use of the model to derive outputs needed to inform investment decisions. The intention is to make Fuel Prophet simpler and more accessible. This is to be achieved through a website with simple inputs and easily accessible features.

The website's home page introduces the model concept, potential outputs and applications, together with a user guide. The user will be able to select the base building, sort and select the measures of interest, and apply fuel price, loan and grant details. Navigation through the model is guided by a simple, numbered sequence of actions, each containing a help message. Buttons on this page allow the user to access graphs such as NPV, amortised NPV, fuel savings, under differing fuel price scenarios, and to print the graphs developed. Separate pages detail the specifications of the base buildings and measures. Measure costs and lifetimes are open to manipulation by the user, complete with the necessary precautions that should be heeded when changing these values.

The website is accessible from the ACE Research website:

www.ukace.org/research/fuelprophet

Several desirable model features have been identified, for development in possible future phases. Feedback from interested users via the website above would be welcome.

The integration of our model with other published work is desirable, notably the Matrix of Measures for hard to treat homes developed by BRE for the Energy Efficiency Partnership for Homes, and Green Street, a website for social landlords to assist them with sustainable refurbishment.

Conclusions

The aim of this project was to construct a method by which decision makers could identify the long term implications of choices to improve energy efficiency of dwellings in their care, in order to help remove the occupants from fuel poverty, under conditions of fluctuating fuel prices. As usual with ambitious projects, more questions have been raised by the findings. On the one hand a useful model has been developed that will aid social landlords and energy policy researchers to consider the implications of investment decisions based on two approaches to 'cost-effective' measures for hard to heat homes. On the other hand, the question "Why would social landlords want to do this?" has been raised and a further set of indicators that would be of more interest to them uncovered.

The method used has indicated that on the whole measures such draft stripping and loft and cavity wall insulation should always be installed first; the measures to follow will depend on fuel price projections. The model shows the disadvantage placed on long-life measures when considering the value of each type for reducing fuel use. Further work is needed to analyse the effects under all the conditions presented in this model, and as such a stream of projects may follow from this one. It is believed to be a sound platform for such work and feedback from stakeholders is always welcome.

ACKNOWLEDGEMENTS

The Association for the Conservation of Energy is very grateful to the Eaga Partnership Charitable Trust for their continued support of our work on the "Affordable Warmth in Hard to Heat homes" agenda.

We are also deeply indebted to our Steering Group and other stakeholders who gave their time and expertise to this project, and whose comments may be cited in the text as personal communications or incorporated into the User Guide on the project website.

Steering Group:

Keith Ross	BRE
Peter Matejic	DTI
Peter Daley	Eaga Partnership
John Chesshire	Eaga Partnership Charitable Trust
Richard Sykes	EDF Energy
Sue Stanton	National Grid Transco
Nick Merleau-Ponty	NEA
John Bird	St Pancras Housing Association, part of Origin Housing Group

Other contributors include Alan Jones, Leeds City Council; Catrin Maby, Severn Wye Energy Agency; Denys Stephens, Penwith Housing Association; Jo Williamson, Sustainable Homes; Naomi Brown, Eaga PCT; Nicholas Doyle, Places for People Group; Alison Malthias, the Housing Corporation; Helen Lee and Andrew Brown, Scottish Power; Pedro Guertler, Senior Researcher at ACE, Mike Hugh, formerly of ACE and now researching fuel cells in Portugal, together with manufacturers and trade organisations who provided information on costs of measures. To all of you, many thanks.