Transforming Northern Ireland's Heating Systems: A Plan to Retrofit Dwellings

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This report was written by Dr Chris Morris of Ulaidh Research Consulting. Dr Morris was a *Northern Ireland Statistics and Research Agency* statistician for over thirty years, working in various departments on a wide range of statistical issues and surveys. Since 2009 he has been working as a self-employed research consultant and is currently a member of the University of Ulster Research Ethics Committee.

Commissioned by: Bryson Energy

This research has been commissioned by Bryson Energy. Bryson Energy is the EU Regional Energy Agency for Northern Ireland and also a member of the Bryson Charitable Group, Northern Ireland's leading social enterprise. Bryson Energy's long term goal is to assist in the eradication of fuel poverty, primarily by energy proofing homes.

The report was supported by Oak Foundation and commissioned in partnership with the University of Ulster.

Foreword

A household is considered to be in fuel poverty if, in order to maintain a safe and healthy level of heating (21^{O}C in the main living area and 18^{O}C in other occupied rooms), it is required to spend in excess of 10 per cent of its household income on all fuel use.

Northern Ireland has one of the highest rates of fuel poverty in the European Union with approximately 42% of households affected. Fuel poverty is a problem that has severe consequences include restricted use of heating, cold and damp homes, debts on utility bills and a reduction of household expenditure on other essential items. In addition, fuel poverty is not only associated with excess winter deaths, but with a wide range of physical and mental health illnesses, such as depression, asthma and heart disease (Marmot Review, 2011).

The main reason for this is a combination of our climate, lower incomes, higher fuel price and a high dependence on oil. In Northern Ireland oil is the most common home heating fuel. Around 68% of households use oil and this rises to over 80% of households in rural areas. This over-dependence on one unregulated fuel means fuel poverty initiatives in Northern Ireland need to address a unique set of challenges which do not exist in other regions of the UK.

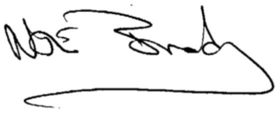
The Department for Social Development NI has run a fuel poverty programme since 2001 which has assisted over £120,000 households at a cost of £150 million. Despite this investment, fuel poverty has increased steadily since 2001. It is clear that a much wider intervention is needed.

Informed by many years' experience of developing and implementing fuel poverty initiatives Bryson Energy firmly believes it is time for a 'whole house' approach to tackle fuel poverty here in NI. This should involve partnership working, trusted delivery partners and targeting to ensure that those most in need are identified. It should also feature a one-stop shop approach including advice and handholding services around energy saving, fuel budgeting and brokering, switching, income maximisation and debt management.

Importantly it also includes a 'whole house' approach in terms of the dwelling itself. Identifying and installing a range of measures that will go some way to 'fuel poverty proofing' the house, rather than the installation of part measures as many schemes have done in the past, we need to look at retrofit and sometimes deep retrofit solutions. We are in no doubt that this retrofit work will require a large level of investment and development of a costed plan involving all key stakeholders if it is to be carried out on any meaningful scale.

We have commissioned this report to put a figure on what this work may cost and what will be the wider implications on fuel poverty targets, climate change targets, renewables targets and job creation. We are delighted with the report, which has been produced by Dr. Chris Morris, a local social researcher and statistician. He has a great deal of knowledge and understanding of the NI housing and fuel poverty context, having formerly been Principal Statistician working within the Department for Social Development NI. The report brings together a very valuable set of data and recommendations on which a retrofit plan fit for Northern Ireland can be based.

I would like to thank Dr. Chris Morris and Professor Christine Liddell, University of Ulster and the Bryson Energy team for their valuable input into this very important piece of work. I would also like to thank Oak Foundation who funded this research alongside a portfolio of ongoing fuel poverty research and programmes in NI. I hope that it helps to inform the debate around fuel poverty in NI and form the basis of a discussion on how we move forward in tackling fuel poverty.



Nigel Brady
Director of Bryson Energy

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A. GENERAL BACKGROUND

INTRODUCTION

1.1 The broad objective of Bryson Energy's interest covered by *Transforming Northern Ireland's Heating Systems: a plan to retrofit dwellings* is to address issues of fuel poverty through retrofit interventions to improve the quality of housing stock in Northern Ireland. It is anticipated that there will also be impacts on other issues of current concern.

1.2 The UK Fuel Poverty Strategy (2001) gives a formal definition of Fuel Poverty in the following terms:

"..a fuel poor household is one that cannot afford to keep adequately warm at reasonable cost. The most widely accepted definition of a fuel poor household is one which needs to spend more than 10% of its income on all fuel use and to heat its home to an adequate standard of warmth. This is generally defined as 21°C in the living room and 18°C in the other occupied rooms – the temperatures recommended by the World Health Organisation"(DEFRA 2001)

1.3 There are other definitions in use, but this highlights the relationship between a) the household income and b) the level of spending that is needed to heat the household to an adequate standard. This relationship is by no means simple, despite the fact that poorer households often occupy poorer quality housing.

1.4 The income of less wealthy households has long been recognised as being largely dependent on access to employment in reasonably well paid jobs (Rowntree 1901, 119). Where such access is restricted by reason of bereavement, caring responsibilities, age, disability or illness, or where wages are low/ employment erratic, poverty results unless provision is made for the support of the household through adequate pensions, benefits and grants. The income of a household is not something that can be directly addressed through an improvement in the housing stock that it occupies, although an improvement in income may well be reflected in a subsequent improvement in housing stock[1].

1.5 The cost of heating a household is dependent on a rather more disparate range of factors. These include:

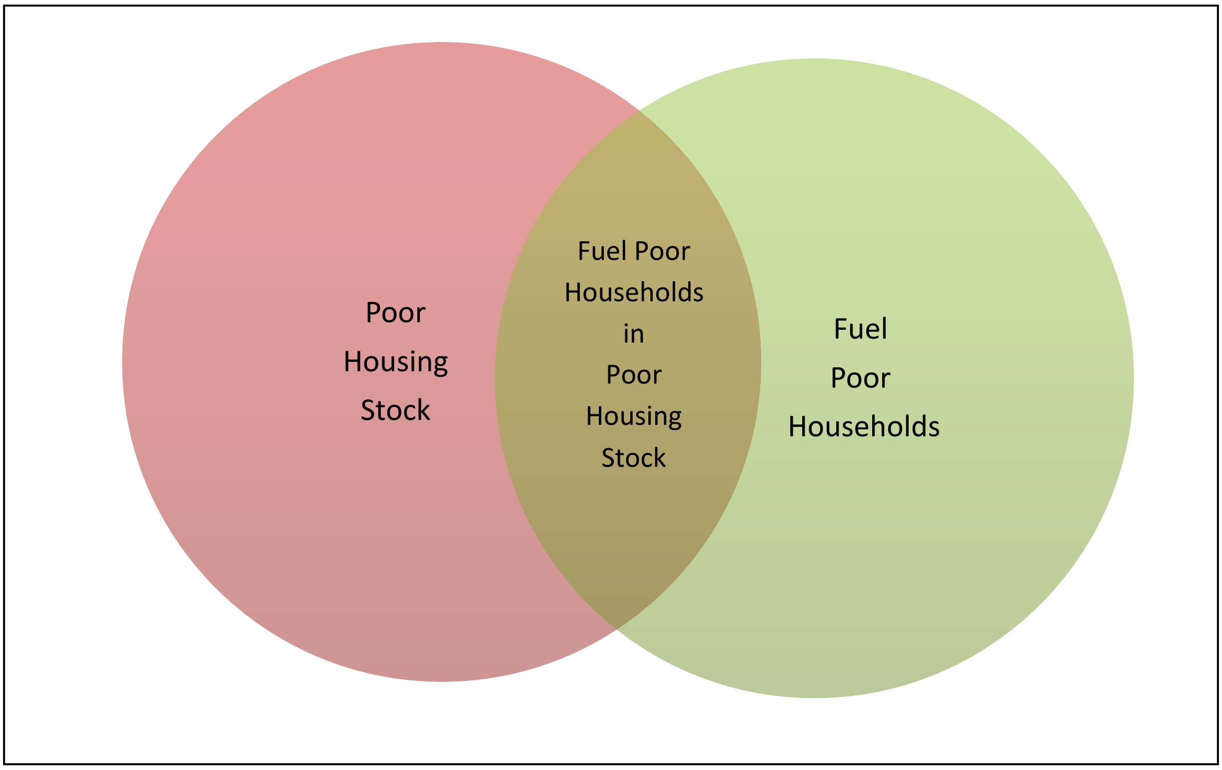
a) The climate and micro-climate of the location where it is found. The reason for having any form of heating at all is that in many parts of the world, the natural environment does not deliver "an adequate standard of warmth". The greater the extent to which the natural environment does not deliver, the greater (and more expensive) the level of heating intervention that is required.
b) The availability and price of fuel. Fuels vary in price, and not all are universally available.
c) The size and configuration of the accommodation.
d) The heating system used. Not all systems are equally effective in generating energy.
e) Insulation. The ability of property to retain heat generated varies.
f) Household life style. Households vary in their vulnerability to cold (the old, the young and the sick), in the number of hours daily and weekly that their premises are occupied, and in the extent to which they are willing to mitigate cold (eg by wearing heavier clothing)

[1] Possession of surplus housing stock by a household may represent a source of income through renting, but more commonly, housing is a cause of expenditure rather than a source of income.

1.6 Of these six factors, only accommodation size/configuration, heating system and insulation can be regarded as relating directly to the quality of the housing stock, and can be impacted by a retrofit. On the other hand, the other three should not be ignored, since they will impact on the efficacy of any retrofit undertaken. Availability of fuels may govern the improvements that are feasible. Directing improvements in housing quality to those areas of greatest need (cold conditions or expensive fuels) may yield greatest benefit. Targeting help to lifestyle may be more difficult or in some instances, even inappropriate (eg targeting help in order to facilitate a desire to wear light clothing around the house), but should not be ruled out.

1.7 It is important to bear in mind that fuel poverty is a household characteristic, while poor housing stock is a concept relating to houses. As Figure 1.1 shows, not all fuel poor households necessarily live in poor housing stock and not all poor housing stock necessarily contains fuel poor households.

Figure 1.1 Relationship of Poor Housing Stock and Fuel Poor Households



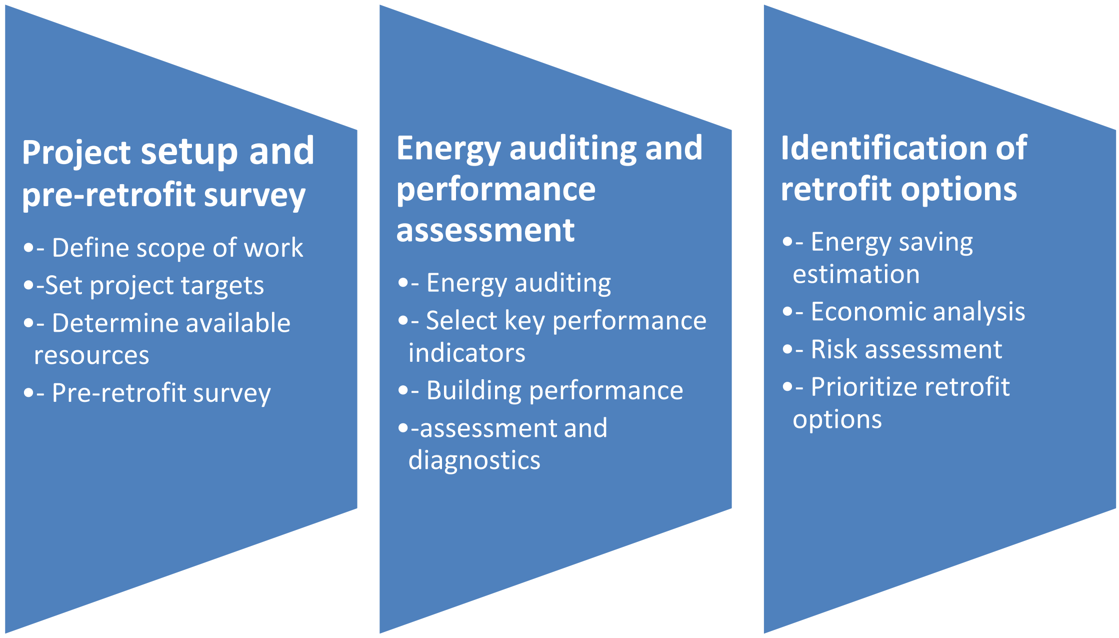
Recommendation

take account of the fact that fuel poverty is not solely a function of household energy efficiency any more than it is solely a function of household income

2 DECISION MAKING

2.1 Ma, Cooper, Daly, and Ledo (2012) identify three initial stages in the decision-making process concerning a retrofit project (as shown in Figure 2.1). In the initial stage of project setup and pre-retrofit survey, it is necessary to define the scope of work, set project targets, determine resources and carry out a pre-retrofit survey. In energy auditing and performance assessment, the characteristics of possible interventions are established in terms of performance indicators, energy outcomes and building effect. This allows identification of options which can be assessed in terms of energy saving, economics and risk, leading to prioritization of the available options.

Figure 2.1 - Key phases of retrofit decision-making process



Source: adapted from Ma et al

2.2 Ferreira, Pinheiro and de Brito (2013) demonstrate that there are a great many models (scores of them) for making decisions about retrofits. These include tools which, in terms of environment, take account of such things as air emissions; CO_2 emissions; convenience; environmental comfort; liquid effluents; energy consumption; physical functionality of buildings with regard to state of deterioration; estimated future deterioration; commercial housing conditions; health; indoor environmental quality; life cycle assessment; life cycle CO_2 emissions; materials and resources; renewable energies; safety; site assessment; thermal comfort; use functionality; water consumption; and solid waste. In terms of economics, they may consider cost of conserved energy; long term effectiveness of investments; investment costs; life cycle cost; net present value; operational costs; or estimated payback time. As well as deterministic calculations, they can also use Monte Carlo procedures and probabilistic calculation.

2.3 Many of these tools have common goals, of which the design of low energy buildings is undoubtedly the most frequently found, but other goals include reducing energy consumption and CO_2 emissions; improving living conditions; and addressing costs.

2.4 Ferreira, Pinheiro and de Brito also suggest that analytical tools should also be considered in their national or regional context, since local problems may differ with region, climate, economy and culture. It is not clear whether the term “pre-retrofit survey” is intended to refer to a building survey, a population survey, or a survey of available data. Any or all would seem to be relevant in different situations. In the context of this report, the term is taken to mean a survey of data, examining whatever is available and relevant to Northern Ireland concerning a range of subjects.

2.5 This, however, is only one of the four activities noted under project setup and pre-retrofit survey. Without a definition of the scope of work, establishment of a project target and a determination of the resources available, it is not possible to progress to the next stage. This is not to rule out the possibility of an iterative process where a preliminary scope, target and resource allocation are assessed in the light of the data survey, and revisited as necessary.

2.6 It is, however, important not to allow the process of planning to become too mechanistic and deterministic. To adapt slightly the words of Sabin (2012, p49), "It is important that [planners] do not become too fixated on the technicalities. Statistics are notoriously difficult to interpret in isolation, there may be large gaps between theory and practice in areas such as equipment performance [...] and human factors tend to have a decisive impact [...] though hard to quantify."

2.7 Cartwright (2013) draws attention to the fact that evidence is not always valid in a different context. It is necessary to pass from awareness that an intervention works somewhere through the view that it works widely to the conclusion that it works in the proposed environment. Factors which work to support the intervention in one place may work differently elsewhere, and even the main causal factor may operate differently (or not at all). This is of particular relevance to Northern Ireland, where there is sometimes a tacit assumption that what works in Great Britain must also work in Northern Ireland (an assumption sometimes made in advance of substantial evidence that the intervention actually works in Great Britain).

Recommendation

seek to ensure that activities are validated for the Northern Ireland context

3 RELEVANT GOVERNMENT POLICIES

3.1 Government has a great many policies relating to housing, energy development, planning and rural-proofing which are likely to impact on any programme of retrofitting. Not all are necessarily designed to be consistent with each other, and when applied in the absence of co-ordination, may result in non-coherent outcomes eg if the installation of solar panels is encouraged by one department in order to develop renewable energy sources and forbidden by another as unsuitable to the character of the neighbourhood where installation is proposed.

Recommendation

advocate and facilitate the co-ordination of government policies on an inter-departmental basis

3.2 As noted elsewhere (Section 6), there are at least eleven UK energy policies interacting with each other, most of them originally based on non-coordinated analysis of data derived from Great Britain, hence of uncertain validity in the Northern Ireland context. Given that it is unlikely that anyone has a clear idea of the likely effects of the individual policies when applied in Northern Ireland, except in those instances where research has been carried out in Northern Ireland to identify the impact of those many factors and circumstances where there are local differences between the province and the rest of the United Kingdom, the net interaction of so many policies must be considered moot.

B. NORTHERN IRELAND BACKGROUND

4 CLIMATE

4.1 Northern Ireland is by no means the coldest part of the United Kingdom in winter, but it has cool summers when heating is often required. July is the only month of the year when the average temperature exceeds the threshold temperature where heating ceases to be required. The application of heating regimes designed for other parts of the UK, such as the South East, where heating systems can often be turned off for long periods in the summer, is therefore inappropriate but it is not unknown.

4.2 Within Northern Ireland, there is a very considerable variation in climate. Table 4.1 shows the extent to which rural, inland and upland areas have a colder climate. There is an 11.3% difference between the heating requirements of Belfast district (average 2052 degree-days[2]) and that of Omagh district (2283 degree-days). Much of this is due to the Belfast heat island and the lower altitude of the city (33.1 metres cf 113.1 metres), though Belfast is also close to the sea, which ameliorates the climate.

4.3 Graph 4.1 shows the extent to which local populations are exposed to lower temperatures and so have relatively high thermal needs by NI standards (the top 20% of needs). The proportion varies from under 10% in Belfast, Carrickfergus and North Down to 40% and above in Strabane, Banbridge, Ballymoney, Armagh and Antrim. This level of variation is not taken into account in the calculation of Northern Ireland fuel poverty, where it is assumed that all NI households experience the average NI climate (it is not clear whether that average is determined by area or by population).

4.4 In summary, therefore:

a. Northern Ireland is warmer in winter, colder in summer, than many other parts of the UK. It cannot be assumed that measures and heating regimes appropriate to the South East of England are equally appropriate to Northern Ireland.
b. There is a considerable sub-regional variation in Northern Ireland, reflecting urban heat islands, altitude and proximity to the sea.
c. The proportion of the population exposed to colder weather varies from under 10% around Belfast to over 40% in the west and centre of Northern Ireland.

Recommendation

take account of climatic variability, since climate is the basic driver of heating need

seek to develop plans so as to make them appropriate to varying sub-regional and local conditions

[2] Degree-days (strictly, heating degree-days) are the cumulated extent to which daily temperatures fall below 15.5°C during a year. This temperature is the point at which heating of houses becomes necessary to ensure acceptable inside temperatures.

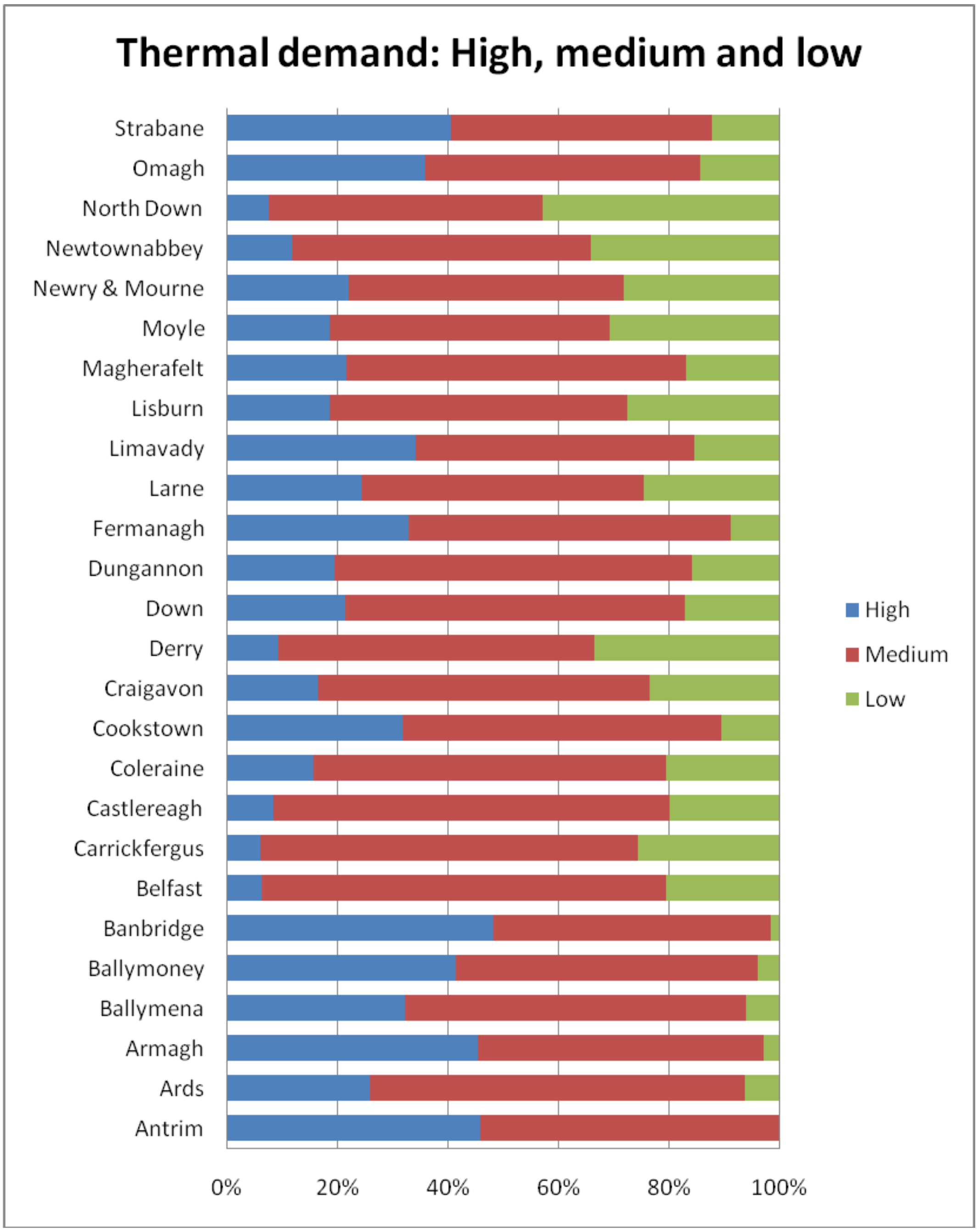
Table 4.1 Altitude and heating requirements 2003-2010 by District Council and for all NI

District	Mean Height	Mean Degree-days	Households	Degree-days (NI=100)
Antrim	57.5	2151	16,994	100.7
Ards	26.8	2081	28,770	97.5
Armagh	76.8	2142	18,682	100.3
Ballymena	79.9	2209	21,772	103.4
Ballymoney	74.0	2201	9,604	103.1
Banbridge	91.8	2214	15,879	103.7
Belfast	33.0	2052	113,319	96.1
Carrickfergus	39.3	2099	14,909	98.3
Castlereagh	60.6	2117	26,782	99.1
Coleraine	36.3	2125	21,558	99.5
Cookstown	78.4	2208	11,043	103.4
Craigavon	38.3	2092	30,661	98.0
Derry	48.2	2164	35,699	101.3
Down	52.6	2115	22,006	99.0
Dungannon	78.3	2185	16,025	102.3
Fermanagh	83.0	2190	20,320	102.5
Larne	73.0	2178	12,319	102.0
Limavady	65.6	2213	10,723	103.6
Lisburn	61.9	2140	40,111	100.2
Magherafelt	70.0	2203	13,040	103.2
Moyle	74.8	2191	5,785	102.6
Newry & Mourne	76.1	2131	29,231	99.8
Newtownabbey	87.8	2198	30,859	102.9
North Down	33.9	2090	31,429	97.9
Omagh	113.1	2283	16,145	106.9
Strabane	69.4	2219	13,053	103.9
Northern Ireland	57.2	2136	626,718	100.0

Source : Liddell, Morris, McKenzie & Rae, 2011 Authors' own estimate of degree-days at Census Output Area level, derived from 18 Northern Ireland weather stations[3]

[3]The daily mean temperature at each of 18 weather stations is converted to sea level equivalent using the mean atmospheric lapse rate and the altitude above sea level of the station. For each of the 5022 Census Output Areas (COAs), the sea level equivalent daily mean is estimated as the average of the 18 weather stations, the data from each station being inversely weighted according to the distance from the station to the centroid of the COA as calculated by grid references. The estimated sea level equivalent is converted into actual temperature, using mean atmospheric lapse rate and altitude of the centroid of the COA, and the actual temperature is adjusted to take account of the probable heat island effect of the settlement type of COA. Degree-days are calculated over a six year period for each COA, and the COA average calculated. COA averages are combined to give district averages.

Graph 4.1 Thermal Demand by District in Northern Ireland 2003-2010



Source : Liddell, Morris, McKenzie & Rae, 2011 Authors' own estimate of degree-days at Census Output Area level, derived from 18 Northern Ireland weather stations

5 HOUSING

5.1 It is important to note the significance, for improving the quality of housing stock, of the distinction between ownership and occupation. Every household occupies some accommodation, but it does not necessarily own that accommodation, and this establishes a certain clash of interests. In rented accommodation, the tenant suffers the immediate inconvenience of improvements, but may perhaps enjoy the future benefits of those improvements if the tenure of the property is secure. The landlord, on the other hand, incurs any cash cost of improvement, and enjoys no future benefit whatsoever unless this is reflected in an increased rent, something to which the tenant is likely to be averse. Even if the property is sold free of Green Deal debt, the landlord is unlikely to find the capital value of the work reflected in the additional price that can be secured[4].

5.2 The willingness of the landlord to accept additional costs varies. Landlords of social housing (NI Housing Executive, Housing Associations) may well be willing to do so, and are, in any case, probably better placed to secure financial assistance from government to cover the costs incurred by them. Success in obtaining the co-operation of this relatively small number of organisations allows large scale province-wide interventions.

5.3 Private landlords, on the other hand, are less likely to accept the burden, and are generally less well placed to secure government assistance. They are also more numerous and more difficult to identify, making substantial direct interaction more difficult.

5.4 Owner-occupiers are very numerous and yet must be engaged individually, in order to persuade them of the advantages of an intervention. Tenure is thus of considerable importance in the implementation of an improvement in the quality of housing stock.

5.5 Table 5.1 shows that in 2010-11 there are about 49,000 vacant properties, out of a total of 759,000 properties in Northern Ireland, leaving 710,000 occupied by households. In this context, 'occupied' is interpreted as furnished and available for immediate occupation (hence liable for payment of rates[5]). Second homes and holiday homes would be regarded as occupied. Since 2001-02, the vacancy rate has risen from 5.7% to 6.4%, and there has been a 13.6% net increase in housing stock (1.4% per annum).

5.6 From Table 5.2 and Graph 5.1, it will be seen that a substantial change has occurred in the tenure of occupied housing stock. In 2001-02, renting from social housing (NIHE and Housing Associations) accounts for 132,300 properties (21%) whilst Private Rented and Other accounts for 44,000 (7%) of housing. Nine years later, in 2010-11, social housing has declined to 115,400 properties (17%) while Private rented has increased to 113,300 (16%). Owner occupation has declined from 72.0% to 67.5%. This shift in tenure has made more difficult the task of implementing improvement in quality of the housing stock.

[4] Since the price of renovations is subject to a surcharge in the form of VAT (currently 20%, although charged at a lower rate for approved energy-related improvements), the balance of the cost-benefit shifts markedly downwards. This is reflected in the price that can be secured vis a vis new property.

[5] The legislation has since changed, so that vacant properties are now liable to rates. There is thus no longer any incentive to inform Land and Property Services that a property is vacant and the quality of the statistics may be expected to deteriorate.

Table 5.1 Northern Ireland properties

Year	Owner Occupied		NIHE		Housing Associations		Private Rented & Other		Total Vacants		Total Stock
	Thousands	%	Thousands	%	Thousands	%	Thousands	%	Thousands	%	Thousands
2001-2002	453.2	67.9	113.4	17.0	18.9	2.8	44.0	6.6	38.4	5.7	667.9
2002-2003	461.0	67.9	105.8	15.6	19.6	2.9	50.5	7.4	42.1	6.2	679.0
2003-2004	471.9	69.0	94.6	13.8	20.5	3.0	57.5	8.4	39.4	5.8	683.8
2004-2005	478.2	68.6	96.6	13.8	21.1	3.0	64.7	9.3	36.9	5.3	697.5
2005-2006	477.8	67.7	93.6	13.3	21.7	3.1	71.3	10.1	41.8	5.9	706.2
2006-2007	487.9	68.5	91.0	12.8	22.3	3.1	64.2	9.0	47.3	6.6	712.6
2007-2008	487.0	66.7	90.0	12.3	24.4	3.3	77.1	10.6	51.4	7.0	729.8
2008-2009	483.9	65.6	89.7	12.2	26.3	3.6	90.6	12.3	46.8	6.3	737.3
2009-2010	483.6	64.3	89.3	11.9	26.8	3.6	98.6	13.1	53.3	7.1	751.7
2010-2011	479.2	63.2	89.1	11.8	28.3	3.7	113.3	14.9	48.7	6.4	758.6

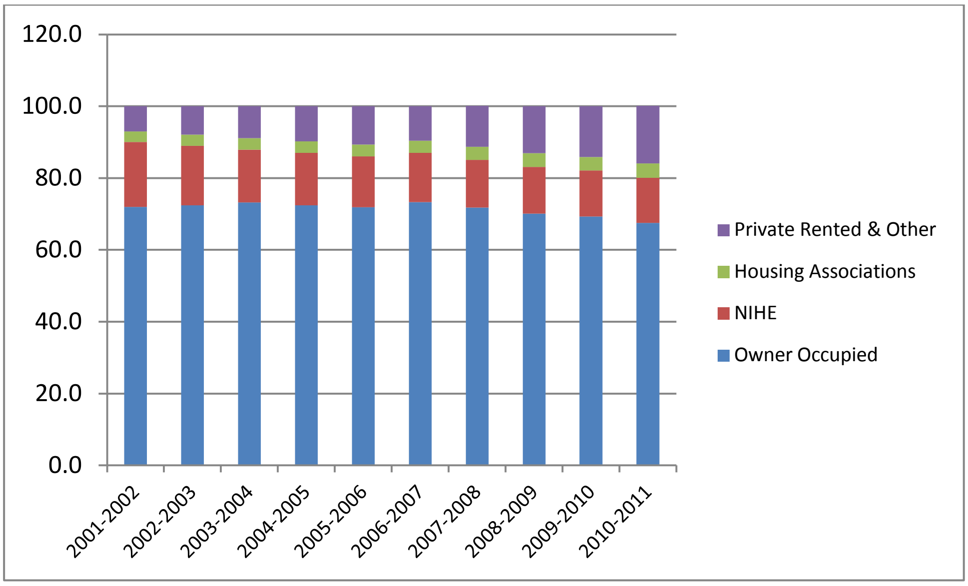
SOURCE: DSD, NIHE, LPS

Table 5.2 Northern Ireland occupied properties

Year	Owner Occupied		NIHE		Housing Associations		Private Rented & Other		TotalOccupiedStock
	Thousands	%	Thousands	%	Thousands	%	Thousands	%	Thousands
2001-2002	453.2	72.0	113.4	18.0	18.9	3.0	44.0	7.0	629.5
2002-2003	461.0	72.4	105.8	16.6	19.6	3.1	50.5	7.9	636.9
2003-2004	471.9	73.2	94.6	14.7	20.5	3.2	57.5	8.9	644.4
2004-2005	478.2	72.4	96.6	14.6	21.1	3.2	64.7	9.8	660.6
2005-2006	477.8	71.9	93.6	14.1	21.7	3.3	71.3	10.7	664.3
2006-2007	487.9	73.3	91.0	13.7	22.3	3.4	64.2	9.6	665.3
2007-2008	487.0	71.8	90.0	13.3	24.4	3.6	77.1	11.4	678.5
2008-2009	483.9	70.1	89.7	13.0	26.3	3.8	90.6	13.1	690.5
2009-2010	483.6	69.3	89.3	12.8	26.8	3.8	98.6	14.1	698.3
2010-2011	479.2	67.5	89.1	12.6	28.3	4.0	113.3	16.0	709.9

Source : DSD, NIHE, LPS

Graph 5.1 Trends in Northern Ireland Tenure by percentage



Source: Table 5.2

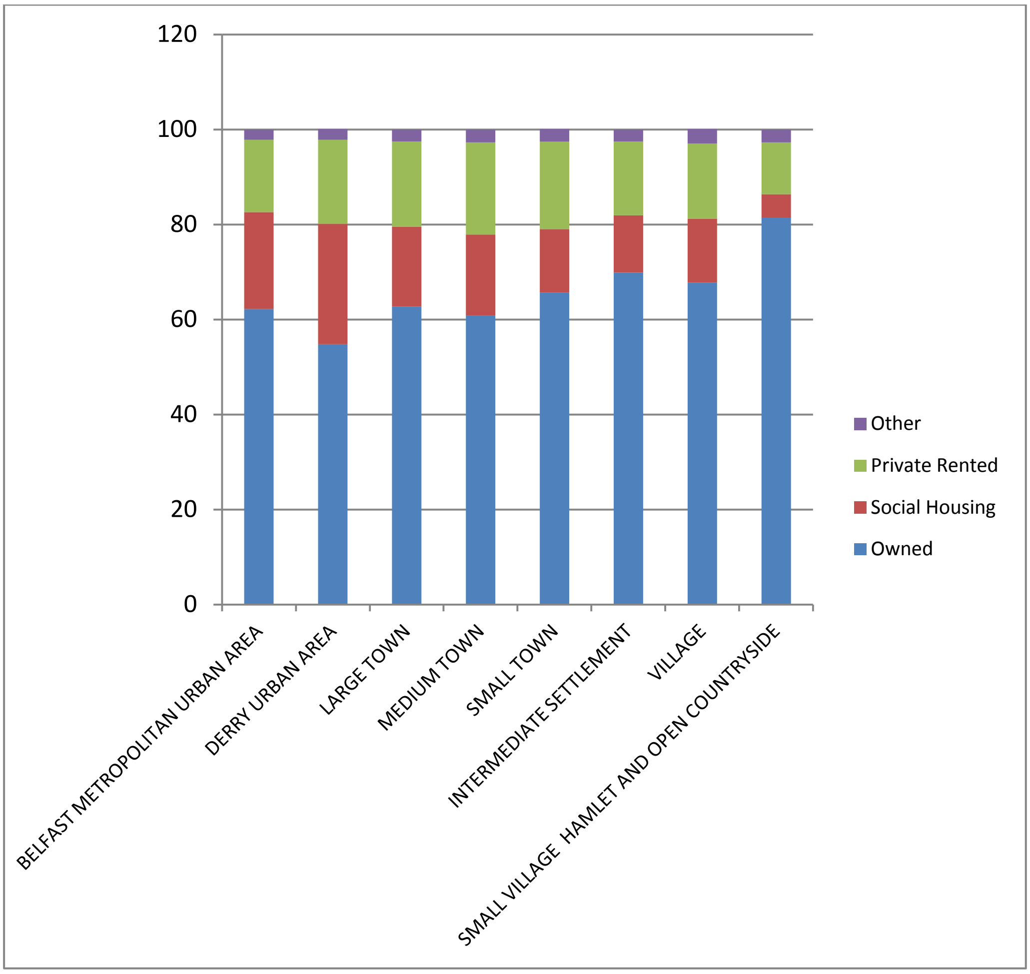
5.7 Table 5.3 and Graph 5.2 show that there is considerable variation by area in the tenure of the properties occupied by households. In Northern Ireland as a whole (2011), two-thirds of households are owner-occupied with about 15% in social housing and a similar proportion in private rented accommodation. Social housing varies from 25% in Derry and 20% in Belfast to 17% in larger towns, 13% in smaller settlements and 5% in the smallest settlements and open country. Private rented accommodation is more common in larger settlements of all sizes (16-19%) and less common in the smallest settlements and open country (11%). Accordingly owner-occupation ranges from 55% in Derry to 62-70% in other settlements and 81% in the smallest settlements and open country.

Table5.3 Tenure of 2011 Northern Ireland Households by settlement type

		Percent			
CLASSIFICATION BAND	Households	Owned	Social Housing	Private Rented	Other
BELFAST METROPOLITAN URBAN AREA	246,966	62.2	20.4	15.2	2.2
DERRY URBAN AREA	34,511	54.8	25.3	17.7	2.3
LARGE TOWN	95,617	62.7	16.8	18.0	2.5
MEDIUM TOWN	42,239	60.8	17.1	19.4	2.7
SMALL TOWN	44,601	65.6	13.4	18.4	2.7
INTERMEDIATE SETTLEMENT	27,769	69.9	12.0	15.6	2.5
VILLAGE	30,673	67.8	13.4	15.8	3.1
SMALL VILLAGE HAMLET AND OPEN COUNTRYSIDE	180,899	81.4	5.0	10.9	2.7
Total	703,275	67.5	14.9	15.1	2.5

Source: 2011 Northern Ireland Census of Population

Graph 5.2 Northern Ireland Percentage Tenure by Location



Source: Table 5.3

5.8 This suggests that the potential for large scale intervention in co-operation with the property owner is greatest in towns and least in the country. Given that 26% of all Northern Ireland households live in the country, compared with 35% in the Belfast Metropolitan Urban Area and 39% in other settlements of 1,000 population or more (with 8% in settlements that are classified as 'rural' by NI definition) this is not an issue that can be readily disregarded, as it might be in the other, markedly less rural, parts of the United Kingdom.

5.9 It will be noted that in 2011, the Census of Population recorded 703,300 households, some of which shared accommodation. Given that 709,900 properties are classified as occupied, it may be concluded that about 7,000 properties were second homes or holiday homes[6].

5.10 Even when the owner of a property is the occupant, the link between dwelling and household is not immutable. People can and do move house, the likelihood of this varying with tenure, age and other circumstances. Recent work by the Electoral Commission on the Northern Ireland Electoral Register has demonstrated that the level of turnover can be high. The Commission reports (Electoral Commission, 2012, 34) that 51% of privately rented households in Northern

[6] Basically, the House Conditions Survey visits a sample of properties and estimates what fraction contains a household (only a household can be in Fuel Poverty), whereas the Census of Population visits all properties and counts households. It is most unlikely that the two methods will come up with precisely the same number of households.

Ireland have lived at their property for less than two years. The corresponding figures for home owners are just 5%. It is entirely possible that an intervention which takes the current occupants of a house out of fuel poverty will not suffice to take the next occupants out (or vice versa), and the change of occupants may come soon. This reduces the robustness of any estimate of household benefits, although deeper retrofit programmes will boost robustness by fuel poverty proofing homes against most family circumstances.

5.11 It is unlikely that tenants with such a high level of turnover will welcome disruption of their occupancy when they will probably not enjoy the benefits. This means that improvements to the property, if they are undertaken at all, are likely to take place between tenancies. This renders it impossible to assess the financial circumstances of the tenant.

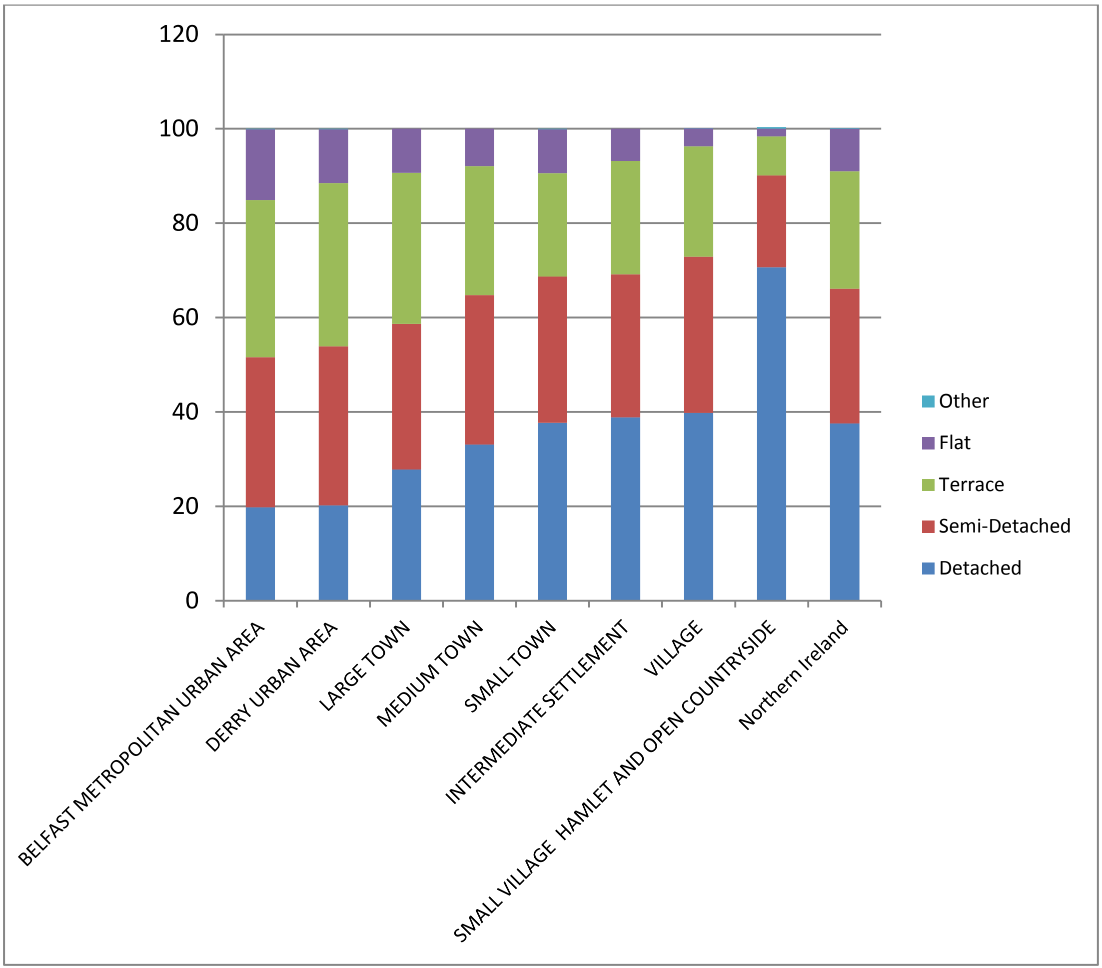
5.12 The nature of property improvements are governed in part by the type of property involved. Table 5.4 and Graph 5.3 shows that in Northern Ireland as a whole, 38% of households occupy detached houses. This, however, is severely misleading at a local level. In the urban areas of Belfast and Derry, it is 20% compared to 28-40% in other settlements and 71% in country areas. Being detached maximises heat loss for any given configuration and construction of property.

Table 5.4 Type of property occupied by 2011 Northern Ireland households by settlement type

CLASSIFICATION BAND	Households	**Percentage**				
		Detached	Semi-Detached	Terrace	Flat	Other
BELFAST METROPOLITAN URBAN AREA	246,966	19.8	31.8	33.3	15.0	0.1
DERRY URBAN AREA	34,511	20.2	33.7	34.6	11.4	0.1
LARGE TOWN	95,617	27.8	30.9	32.0	9.3	0.0
MEDIUM TOWN	42,239	33.1	31.7	27.3	7.9	0.0
SMALL TOWN	44,601	37.7	31.0	21.9	9.3	0.1
INTERMEDIATE SETTLEMENT	27,769	38.9	30.3	24.0	6.8	0.0
VILLAGE	30,673	39.8	33.1	23.4	3.8	0.1
SMALL VILLAGE HAMLET AND OPEN COUNTRYSIDE	180,899	70.7	19.4	8.3	1.6	0.4
Northern Ireland	703,275	37.6	28.5	24.9	9.0	0.2

Source: 2011 Northern Ireland Census of Population

Graph 5.3 Northern Ireland Percentage House Type by Location



Source: Table 5.4

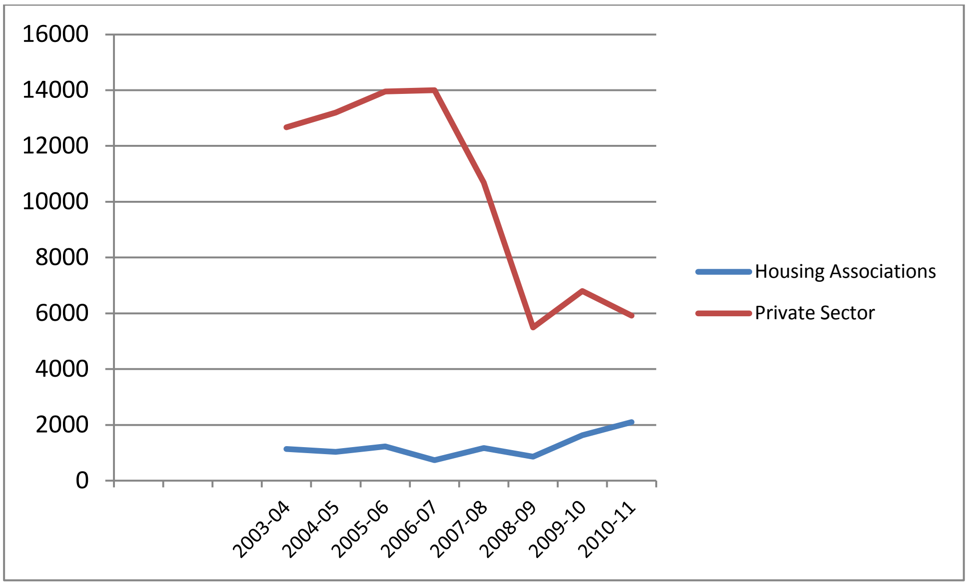
5.13 Table 5.5 and Graph 5.4 show that private sector housing starts form the majority of housing starts, although its proportion of all starts has fallen from 90-95% prior to the 2008 recession to 74-79% in 2010-2012.

Table 5.5 Housing Starts

Year/ Quarter	Housing Associations	Private Sector	Total All Sectors
2003-04	1,140	12,671	**13,811**
2004-05	1,029	13,199	**14,228**
2005-06	1,229	13,955	**15,184**
2006-07	732	13,999	**14,731**
2007-08	1,167	10,684	**11,851**
2008-09	863	5,493	**6,356**
2009-10	1,625	6,802	**8,427**
2010-11	2,104	5,913	**8,017**
2011-12	1,221	4,481	**5,702**

Source: Housing Statistics Table 1.7

Graph 5.4 Northern Ireland Housing starts



Source: Table 5.5

5.14 Table 5.6 shows that build of rural single dwellings, whether new or replacement, form a substantial part of planning business (4,271 decisions in 2010-11 and 3,809 in 2011-12). These decisions do not necessarily result in a house start in the same year, or indeed ever, but it is clear that building of rural single dwellings is currently a major part of all building.

Table 5.6 Housing Planning Decisions

Classification	**Decisions**	
	2010-11	**2011-12**
Rural New Single Dwellings	3,146	2,883
Rural Replacement Single Dwellings	1,125	926
Rural Extensions and Alterations	1,111	906
Urban New Single Dwellings	324	312
Urban Replacement Single Dwellings	95	72
Urban Extensions and Alterations	3,051	2,360
Housing Developments	1,234	815
Other Residential	1,674	811
Total	**11,760**	**9,085**

Source: Housing Statistics Table 1.15

5.15 In summary, therefore:

a. Tenure, whether owner occupation, social rented or private rented, has an effect on the willingness of households and/or owners to participate in improvements. Different approaches to implementation of improvements will be required.
b. There are about 759,000 properties in Northern Ireland, of which 49,000 are vacant.
c. Since 2001, there has been a small decline in owner-occupation, and a marked shift from social rented to private rented.
d. Owner-occupation is most common in the open country.
e. With 26% of NI households lying in the country, the issue of rurality is not one that can be readily disregarded.
f. There are about 703,300 households In Northern Ireland, and about 7,000 properties are occupied as second homes or holiday homes.
g. Turnover of households in properties is ten times higher for private tenants, compared with owner-occupiers. This makes it likely that private landlords will prefer to improve a property when it is vacant.
h. Detached properties, which are intrinsically least energy efficient, are most common in the country.
i. Private sector housing starts form the majority of housing starts (74-79% post recession, which reduced the proportion).
j. It is clear that build of rural single dwellings, whether new or replacement, is currently a major part of all building.

6 DOMESTIC ENERGY USE

Statistics

6.1 Energy statistics for Northern Ireland are, for a variety of reasons, less well developed than those for Great Britain, and their quality has come under criticism. Tol (2011) remarks that he "did the best he could with the data he could find, but the shortage of information was disappointing. 'There's big black holes in data availability,' he comments. 'Some data simply aren't there. Some data, while they are there, are not accessible.' That problem was caused by a "very secretive" public sector working in 'silos, and not talking to each other and not communicating' and also a 'certain amount of neglect' from the UK Government. Northern Ireland is 'not something that is high on the list of priorities for the people who collect the official statistics for what they call the UK, but in effect is Great Britain.'"

6.2 Caution is required with the customer figures published by the Utility Regulator for Northern Ireland. According to the Regulator (2013, p16), there were about 786,000 customers in the final quarter of 2012. From previously published quarterly figures, this implies a growth of 20,000 per year, whereas government figures on house construction suggest about 8,000 houses built in 2010-11 and 5,000 in 2011-2012. There seems little evidence for increased construction of the order implied by the Regulator's figures.

Recommendation

advocate, as opportunity arises, the improvement of statistics on energy utilities

Gas Network

6.3 Prior to the advent of North Sea and other natural gas, the heating systems used in Northern Ireland were broadly similar to those in Great Britain, save that peat was a rather more commonly used solid fuel. In the late seventies and early eighties, however, rather than convert the town gas systems of Northern Ireland to burn natural gas (in parallel with developments in Great Britain), the Northern Ireland government elected to close them down. The economics of conversion would have required the provision of gas at a price that, though attractive to customers and profitable to the supplier, would have undercut the prices of the (then) state-owned Northern Ireland Electricity, increasing the government subsidy to that enterprise. When Phoenix Gas commenced operations in 1996, it was thus necessary for whole new gas pipeline networks (rather than simply trunk distributors) to be constructed, with the attendant cost and inconvenience to all. In the intervening period, domestic consumers had largely switched to oil, at their own expense in the case of owner occupiers.

6.4 Installing gas boilers is only possible in the area covered by the existing pipeline network (theoretical coverage and actual access are by no means the same thing, and subsequent use is another matter again[7]). Although there are plans to extend the network, the location and timing of such extensions are still dependent on the working of the planning system. About 30% of properties in Northern Ireland currently have access to gas (see Table 6.1), although only about 2% of the area of Northern Ireland has access to gas. This reflects the current urban focus of supply. Nearly 70% of properties in Belfast Metropolitan Urban Area (55% of its area) have access to gas compared with 8-28% of properties in Derry Urban Area and towns (4-21% of area). This falls to about 1% of rural properties (0.5-1% of area).

[7] McFarland (2013, p16) estimates that 54% of households in Census Output Areas with access to gas use it. This rises to 75% in COAs with high levels of social housing and benefit receipt. These, of course, are households with little or no choice in the heating that is installed in their accommodation.

Table 6.1 Current Access to Gas

Proportion of Census Output Area with access to gas (as measured by postcodes with gas)		
Classification of Census Output Area	Mean (weighted by properties in the unit)	Mean (weighted by area of unit)
BELFAST METROPOLITAN URBAN AREA	0.692	0.554
DERRY URBAN AREA	0.229	0.113
LARGE TOWN	0.267	0.211
MEDIUM TOWN	0.075	0.044
SMALL TOWN	0.116	0.072
INTERMEDIATE SETTLEMENT	0.012	0.010
VILLAGE	0.008	0.005
SMALL VILLAGE HAMLET AND OPEN COUNTRYSIDE	0.014	0.006
Northern Ireland	0.297	0.023

Source: Area-Based Algorithm database (ALGY-6)

6.5 Currently, seven of the twenty-six district councils have no access at all to gas. Although it is planned to extend the network across the majority of these, it should be noted that the objective is to connect district towns, rather than the surrounding rural hinterland. In towns outside the Belfast area, the population of the rural hinterland forms about 65% of the entire population of a catchment area, with 35% in the district town.

6.6 Recent (January 2013) government announcements concerning the expansion of the network to towns in the west of the province seem to have an optimistic time table, suggesting that construction work might begin in January 2015,with the aim of supplying 34,000 more business and domestic consumers (South Side Advertiser 2013, 21)

6.7 Assuming that the extension of the mains pipeline system enhances access to a level of 70% of properties in Belfast, 30% of all properties in towns other than Belfast and 2% of properties elsewhere[8], the increase in domestic properties with access to gas is likely to be about 13% (27,000) in Northern Ireland as a whole (see Table 6.2). If access in each type of settlement increases to the postulated (plausible) level in Table 6.2, the overall increase would be as shown. It is worth noting that about a third of the population in Northern Ireland lives in settlements, smaller than small towns, which are unlikely ever to receive gas supplies.

Recommendation

take account of the prevalence of less easily heated property in rural areas

[8] Peripheral parts of a settlement are less readily brought into a distribution network. Population density declines and supply lines include a greater proportion of low population density rural space in their catchment zone. The population of peripheral locations as a proportion of the total population in a settlement declines as overall settlement size increases, broadly in line with the formula:

2 / population x 100

Table 6.2 Possible Future Access to Gas (historic household numbers)

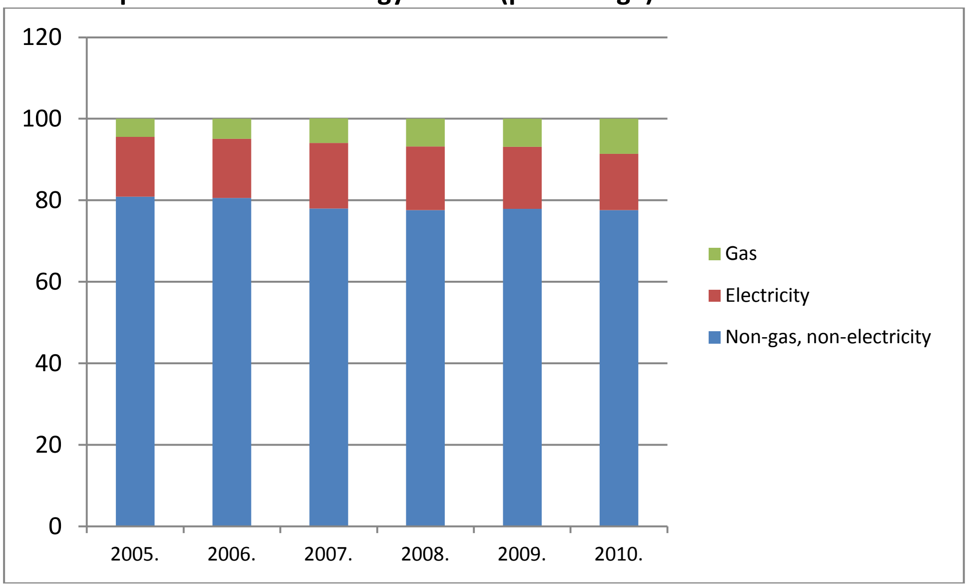
Classification of COA	Households (ALGY 6)	Households 2011	Gas Access	Households with access	Target	Target Outcome
BELFAST METROPOLITAN URBAN AREA	214,165	246,966	0.692	170,900	0.7	172,876
DERRY URBAN AREA	28,880	34,511	0.229	7,903	0.3	10,353
LARGE TOWN	85,483	95,617	0.267	25,530	0.3	28,685
MEDIUM TOWN	38,675	42,239	0.075	3,168	0.3	12,672
SMALL TOWN	41,205	44,601	0.116	5,174	0.3	13,380
INTERMEDIATE SETTLEMENT	24,996	27,769	0.012	333	0.02	555
VILLAGE	28,794	30,673	0.008	245	0.02	613
SMALL VILLAGE HAMLET AND OPEN COUNTRYSIDE	170,820	180,899	0.014	2,533	0.02	3,618
Northern Ireland	633,018	703,275	0.297	208,873	0.336	236,300

Source: Area-Based Algorithm database and 2011 Census of population

Energy Consumption

6.8 Table 6.3 and Graph 6.1 provide a composite estimate of Northern domestic energy consumption over the period 2005-2010, drawn from a variety of sources. The impact of variations in temperature and the increasing numbers of gas customers mean that simple linear extrapolations are poor indicators both of the aggregate consumption and the sourcing of the energy used. Despite the fact that the proportion of energy derived from gas almost doubled (from 4.4% to 8.6%), this growth was not solely at the expense of non-gas, non-electricity energy. In colder years such as 2010, the relative importance of electricity, which is largely used for non-heating purposes, is reduced.

Graph 6.1 Domestic Energy source (percentage)



Source: Table 6.3

Table 6.3 Domestic energy consumption in Northern Ireland

	Estimated TotalGWh					
Source	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Non-gas, non-electricity	16,333.4	17,029.0	15,339.6	15,896.8	16,115.0	17,973.7
Electricity	*2,966.9*	*3,069.9*	3,162.0	*3,192.2*	*3,146.1*	*3,189.4*
Gas	*895.2*	*1,038.0*	1,172.3	*1,384.4*	*1,420.2*	*1,986.8*
Total	*20,195.4*	*21,136.9*	19,673.9	*20,473.4*	*20,681.2*	*23,149.9*
Percent						
Non-gas, non-electricity	*80.9*	*80.6*	78.0	*77.6*	*77.9*	*77.6*
Electricity	*14.7*	*14.5*	16.1	*15.6*	*15.2*	*13.8*
Gas	*4.4*	*4.9*	6.0	*6.8*	*6.9*	*8.6*
Degree-days	2,160	2,179	2,019	2,255	2,176	2,682

NOTES

Non-gas, non-electricity energy derived from DECC published data, bio-energy and wastes allocated to domestic sector, pro rata to domestic sector share of all other sources.

Electricity extrapolated from DECC published experimental data (2008 & 2009) on consumption, using published generation data 2005-2010

Gas extrapolated from 2007 regulators estimate, based on DETI published source share of domestic heating consumption, approximate trend in customer numbers, variation in temperature and assumed growth of 0.1% in per capita non-heating use of energy.

Gas customer numbers are taken from tables in published regulator reports, estimated from graphs in the same sources, or interpolated.

Temperature variation is derived from annual degree-days published by VESMA

6.9 Table 6.4 shows that the number of electricity customers rose from 755,000 in 2005 to 767,000 in 2010 and (on the assumption that consumption of electricity is universal) so did the total number of customers. It should be borne in mind, however, that the "customers" are not households, since in 2011, the Census of Population found only 703,000 households in Northern Ireland. The additional 67,000 or so customers (almost 9%) are in fact multiple meters (about 11,000), second/holiday homes (about 7,000) and vacant properties (about 49,000). This emphasises the distinction between people and property. The table assumes that the increase in gas customers, averaging about 13% per annum, is matched by a corresponding decrease in non-gas, non-electricity customers.

Table 6.4 Trends in Customer numbers

Group	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Customers (NGNE)	674,994	665,384	648,184	643,363	638,542	622,248
Customers (Electricity)	754,994	757,384	759,773	762,163	764,553	766,942
Customers (Gas)	80,000	92,000	111,589	118,800	126,011	144,695
Customers (NI)	754,994	757,384	759,773	762,163	764,553	766,942
Annual % increase in Gas	na	15.0	21.3	6.5	6.1	14.8
Average % increase in Gas	12.7					

NOTE There are more customers than households or properties in Northern Ireland, due to multiple meters in properties, vacant properties and second/holiday homes

NGNE: Not Gas, Not Electricity

6.10 Table 6.5 shows the sources of domestic heating energy in Northern Ireland, demonstrating the dominance of oil, with gas and electricity accounting for only 11% of energy consumed. This compares with approaching 25% of all domestic energy. A very large part of electricity consumption and some gas consumption is used for cooking and powering devices, rather than heating. Renewables are currently a fairly minor component of domestic heating. Phase 2 of the NI RHI is designed to support take up in the domestic sector and NI has overall targets of 4% renewable heat by 2015 and 10% by 2020.

Table 6.5 Sources of heating energy in Northern Ireland

Fuel / Energy type	Domestic (GWh)	Industrial, Commercial and Public (GWh)	Total (GWh)	Percentage of Total	Percentage of Domestic
Oil	9,241	4,103	13,444	77.0	86.5
Gas	973	1,991	2,964	17.0	9.1
Electricity	176	41	217	1.2	1.6
Renewables *	178	112	290	1.6	1.7
Coal	110	438	547	3.1	1.0
TOTAL	10,678	6,685	17,362		

*Sectoral split of consumption estimated from the split of other consumption
Source: DETI (2011) The Development of the Northern Ireland Renewable Heat Incentive
Year of data unspecified

6.11 Table 6.6 shows that between 2001 and 2011, the proportion of properties without central heating dropped from small (5%) to tiny (1%). While gas central heating increased from 4% to 17%, this appears to have been at the expense of other non-oil central heating (33% declining to 14%) rather than oil (58% rising to 68%).

Table 6.6 Prevalence of Central Heating

Central Heating	**2001**	**2004**	**2006**	**2009**	**2011**
	%	%	%	%	%
Non Central Heating	**5**	**3**	**2**	**1**	**1**
Central Heating	**95**	**97**	**98**	**99**	**99**
Gas	4	8	12	15	17
Oil	58	65	70	68	68
Solid Fuel/Electric/Dual Fuel/Other	33	24	16	15	14
All Dwellings	**647,530**	**680,000**	**705,000**	**740,000**	**760,000**

Source: Table 2.1 Housing Statistics

Renewables and Carbon Generation

6.12 At the back of customer bills, Power NI (2013) state that in 2011, 1.6% of their overall generation was derived from renewable sources (compared with 17.2% for the All Island Market), with 71.3% fuelled by natural gas (cf 56.2%). Other sources of energy contributed virtually identical proportions of energy for both Power NI and the All Island Market. In terms of carbon emissions, Power NI also states that it generates 0.535 tonnes of CO_2 per MWh, compared with 0.466 tonnes per MWh for the All Island market (a difference of 0.069 tonnes per MWh). Since renewable sources are deemed to have zero carbon emissions, this suggests that natural gas is a fairly low carbon emitter (of the order of 0.450 tonnes per MWh) compared with the other fuel sources.

6.13 Table 6.7, based on a published table of the Biomass Centre, suggests that the Power NI figure of 0.535 tonnes of CO_2 per MWh of electricity is very close to the 0.530 tonnes shown by the Biomass Centre for the UK grid as a whole. The Biomass Centre shows, however, that the figure for direct burn of natural gas is 0.270 tonnes, which is substantially lower than the deduced value of 0.450 tonnes. This gives a measure of the inefficiency of grid generated electricity as a heat source, suggesting that it requires an output of carbon dioxide at least two-thirds higher than providing it through a direct burn. it is much more efficient to burn a primary fuel (e.g. gas or oil) to produce heat than to use electricity for heating since conversion losses have already been incurred while generating electricity from primary fuels. i.e. Power stations are only 35% to 58% efficient. Even the best CCGT plant are still below 60% efficient.

6.14 The table also shows that a “typical” house (consuming 20,000 kWh per annum for heating)[9] generates 30% more carbon dioxide when using oil rather than gas.

6.15 A rough calculation suggests that if the number of gas customers increased by 12.7% (average annual growth rate over the period 2005-2010), the switch of about 18,400 customers from non-gas, non-electricity to gas would reduce carbon generation by 1.75%.

Carbon policy and taxation

6.16 There are issues of equity connected to carbon dioxide emissions by private consumers, and the government policies being applied to reduce them. Hargreaves, Preston, White, and Thumim(2013) examine the levels of carbon dioxide emission by households in Great Britain and show that home carbon dioxide emission by the top decile of households, by income, is double that of the lowest decile (rising to treble when the effects of travel are added in). The more rural an area[10], the greater the carbon dioxide emission with households in villages etc producing a quarter more carbon dioxide than urban households for home use (a fifth more overall)

6.17 Preston, White, Thumim, Bridgeman, and Brand (2013) extend this work by looking at theimplications for UK domestic energy policy (as so often, a UK policy is based on a GB analysis). They look at the impact of eleven (!) different policies for carbon reduction and show (p86) that while urban households benefit by a reduction of £85 per annum, for towns it is £59, villages £24 and open country has no benefit, with an increase of £126. They consider that fuel poverty retrofit policies are likely to be less effective in rural areas. The researchers direct attention to the triple injustice of a system where poorer households, though contributing less to the basic problem, find themselves paying for remedial measures that are directed to deliver benefits to wealthier households. Browne, Dresner, Ekins, Hamilton, Preston and White (2013) examine the issue of designing carbon taxation to protect low-income households, given that transport energy and domestic energy are taxed in radically different ways.

[9] How typical such a house is of Northern Ireland is of course debateable, given that Table 6.3 implies energy general consumption about 33,000 kWh per annum per household and Table 6.5 implies 15,200 kWh per annum heating consumption per household. Oil and gas consumption, combined, per household is about 25,000 kWh per annum. Care is required with interpretation of “typical” situations. Advertising for energy quotes as “typical” energy costs for semi-detached houses, even though in no part of Northern Ireland do such houses form so much as a third of the housing stock (or the most common form of housing stock). Presumably, it would be more correct to state that potential customers typically occupy semi-detached houses.

[10] The categories are urban (population 10,000 and over cf NI 5,000 and over); town & fringes; village, hamlet and isolated dwelling

Table 6.7 Carbon emission of various fuels

Fuel	Net calorific value (MJ/kg)	Carbon content (%)	Approx. life cycle CO_2 emissions (including production)		Annual total CO_2 emissions to heat a typical house (20,000 kWh/yr)		
			kg/GJ	kg/MWh	Kg	kg saved compared with oil	kg saved compared with gas
Hard coal	29	75	134	484	9680	-2680	-4280
Oil	42	85	97	350	7000	0	-1600
Natural gas	38	75	75	270	5400	1600	0
LPG	46	82	90	323	6460	540	-1060
Electricity (UK grid)	-	-	150	530	10600	-3600	-5200
Electricity (large scale wood chip combustion)	-	-	16	58	1160	5840	4240
Electricity large scale wood chip gasification)	-	-	7	25	500	6500	4900
Wood chips (25% MC) Fuel only	14	37.5	2	7	140	6860	5260
Wood chips (25% MC) Including boiler	14	37.5	5	18	500	6500	4900
Wood pellets (10% MC starting from dry wood waste) See note	17	45	4	15	300	6700	5100
Wood pellets (10% MC) Including boiler See note	17	45	7	26	660	6340	4740
Grasses/straw (15% MC)	14.5	38	1.5 to 4	5.4 to 15	108 to 300	6892 to 6700	5292 to 5100

Note: These figures for wood pellets include the hammer mill and pelleting process, however do not include sourcing the feedstock and any pre-processing such as drying. If starting from green wood then drying could be a very major component, however pellets are often made from dry waste wood that has been dried for another purpose, such as joinery. These figures also do not include transport (which is included in the figures for wood chips).
MC: Moisture Content
Biomass Energy Centre (12/03/2013)

6.18 It is unclear exactly how this may be read across to Northern Ireland. The primary data source for the work of Hargreaves et al is the Expenditure and Food Survey (EFS), which is a UK sample and for the years investigated, has an enhanced NI sample, allowing detailed analysis of

Northern Ireland conditions. A secondary source is the National Travel Survey, which is a GB survey with a NI analogue carried out, so that it seems likely that a NI approximation to GB results could have been achieved from that. Since, however, the key adjustment from the financial data of EFS to carbon dioxide emissions information depends on price data which in an accessible form for gas and electricity is lacking regarding Northern Ireland, the researchers have opted to restrict their analysis to Great Britain.

6.19 Some degree of extrapolation is, however, possible. It is reasonable to suppose that higher income households are responsible for more carbon dioxide emission in Northern Ireland, just as in Great Britain, (but because the range of household incomes is less in Northern Ireland, the differential is likely to be less between richest and poorest). This is reinforced by the more rural nature of Northern Ireland, with lower incomes in the rural west, where natural gas is for the most part unavailable and oil is the fuel used, with higher levels of carbon dioxide emission (absence of public transport and longer travel distances to services augment the effect, when travel is taken into account). These are effects reported by Hargreaves et al, but likely to be more marked in Northern Ireland than in Great Britain as a whole.

6.20 The likelihood is that carbon policy and taxation work to the disadvantage of Northern Ireland. (See Annex 1 for comments on Northern Ireland taxation and expenditure. There is no automatic read across from the situation in Great Britain to that in Northern Ireland.) The work of Preston et al shows that the interaction of the eleven policies they examine works to the disadvantage of dispersed rural populations (not villages) in Great Britain. This pattern of settlement is more generally found in the North and West of England, Wales and Scotland. Northern Ireland has a similarly dispersed rural population and may well suffer in a similar way from policies devised largely from an urban perspective. The Northern Ireland commitment to rural-proofing policies, if carried out robustly, might well mitigate against their adoption, to the extent that Northern Ireland has any say in the matter.

6.21 Use of renewable energy is not quite the same as saving of carbon emissions. It directs production away from the use of fossil fuels to produce energy (and the accompanying release of the carbon which was trapped in such fuels during geological times) to the use of energy sources which are either not directly carbon dependent (eg wind, wave, hydro-electric, solar, geothermal etc) or else recycle carbon in short-term capture and release (eg wood pellets – when not dependent on deforestation, but accompanied by re-afforestation – or methane generation from sewage).

6.22 Natural gas is a low carbon emitter, by comparison with oil, coal or peat though it is no more a source of renewable energy than they are (see Annex 2 for some comments on peat in Ireland, where the extent of lowland peat is relatively greater than in Great Britain). Consequently, a switch from oil or solid fuel to gas, assuming that consumption of renewables remains constant, produces an increase in the percentage of carbon emission due to renewable sources, rather than an increase in percentage of energy due to renewable sources.

6.23 It must be borne in mind that renewable sources which release carbon into the atmosphere are only deemed "renewable" on the basis of a promise, implied or explicit, to implement and maintain measures to replenish supplies of the fuel and re-fix the carbon released. In the absence of such a promise, burning wood pellets or cow dung is no more renewable than burning peat or anthracite. (The EU Renewable Energy Directive (RED) contains sustainability criteria for biofuels. See also DETI website re NI RHI.)

Renewable and passive gain energy sources

6.24 Wood burning kit appears to be rather cheaper than other renewable kits such as air and ground source heat pumps, solar photovoltaic panels and wind turbine (see Tables 12.1 and 12.2). On the other hand, it has considerable disadvantages. It depends on the purchase of a fuel that is both bulky to store and low in energy content (half that of an equivalent weight of coal and on average about one fifth that of an equivalent volume of coal)[11]. Burning this produces a waste product, wood ash, which has to be disposed of, at a time when local authorities are exerting pressure on households to reduce landfill waste. There are other ways[12] to dispose of wood ash, possibly better suited to rural circumstances, but handling wood ash is unpleasant since it is corrosive (being rich in oxides/hydroxides of calcium and potassium) and dusty, which is conducive to a range of respiratory diseases. As implied by paragraph 6.23, wood is only truly carbon neutral and renewable when the timber burned has been re-planted and re-grown to its full extent. For this reason, it cannot be regarded as immediately renewable, and there is a strong fiduciary element in its use.

6.25 There is a great deal of kit available for solar warming and photovoltaic retrofits, but the effectiveness of this is very much influenced by orientation of the building (See Annex 3). Effectiveness is also affected by the skill of installation. Given the relative newness of the technology, this skill cannot be fully relied upon at present[13]. Skills will, no doubt, improve over time.

Table 6.8 Heat sources for some Northern Ireland building designs

House Type:	**Terrace**	**Detached**				
Design:	**2**	**1**	**3**	**4**	**5**	**Average detached**
Location	Eglinton	Hillsborough	Newtownabbey	Drumbeg	Ballymena	
Area (sq m)	51	161	192	138	156	162
Auxiliary Heating (kWh)	3,084	10,398	13,763	8,861	8,881	10,476
Solar Gain (kWh)	1,087	7,814	6,113	6,896	7,419	7,061
Casual Gain (kWh)	3,478	6,759	6,780	6,022	6,759	6,580
Total (kWh)	7,649	24,971	26,656	21,779	23,059	24,116
Solar Gain as % Total	14.2	31.3	22.9	31.7	32.2	29.3
Auxiliary heating (kWh) per sq m	60.5	64.6	71.7	64.2	56.9	64.8
Solar gain + Auxiliary heating (kWh)	4,171	18,212	19,876	15,757	16,300	17,536
Solar gain + Auxiliary heating (kWh) per sq m	81.8	113.1	103.5	114.2	104.5	108.4

Source: O'Cathain&Howrie

6.26 O'Cathain & Howrie (1994) analyse some house designs produced in a Northern Ireland context, with a view to maximising passive solar gain (see Table 6.8). Most are for rather upmarket detached properties and on average, they are able to secure about 30% of the heat required through passive solar gain, leaving the rest to come from other sources. Auxiliary heating amounts to about 65 kWh per square metre. For the terraced design, under 15% of heating comes from solar gain, so that auxiliary heating amounts to 61 kWh per square metre. This

[11] It may also be noted that Ireland is the least afforested country of Europe, excluding Iceland. Imported wood is required.

[12] For example, as fertiliser or in soap manufacture.

[13] For example, a electrical heating circuit intended to be activated as a supplement at external temperatures of -13°C being installed in a permanently activated – and hence very expensive - state (personal anecdote).

suggests that large detached properties have some advantages in making use of Northern Ireland's none too abundant solar energy resources, if this is built in from the start. When, however, retrofitting extends to radical redesign of a property, it is possibly better described as rebuilding. Many single new properties in the country have in fact replaced an older property that has been subsequently abandoned.

6.27 The auxiliary heating could, in theory, be any energy source and in the circumstances of today, is likely to include renewable energy sources. At the time, one design consultant, in dismissing coal, LPG and electricity as central heating fuels, wrote (O'Cathain & Howrie, Design 3, p29) "Oil has been chosen ... It is the more traditional fuel used in Northern Ireland."

6.28 Solar gain plus auxiliary heating in the 1994 designs is about 4,200 kWh for the terraced property and averages 17,500 kWh for the detached property. Assuming that the intentionality of the design process shifted the balance from auxiliary heating towards solar gain, it is reasonable to suppose that more standard detached designs may have required something like 15,000 kWh of heating (which would be consistent with Table 6.5, above).

6.29 In summary, therefore:

a. The existing town gas system of Northern Ireland was closed in the early eighties rather than converted to natural gas, imposing a protracted and expensive re-opening of the network, when natural gas was introduced in 1996.
b. Despite plans to extend the broad coverage of the gas network to all parts of Northern Ireland, this will not reach the whole population, with the rural population remaining largely excluded. At best, 70% access seems the maximum level achievable (27,000 more households brought in scope).
c. The quality of statistical information on electricity and gas supply in Northern Ireland is not good.
d. Gas consumption has increased in the period 2005-2010, partly due to colder winters.
e. Between 2001 and 2011, the proportion of properties without central heating dropped to 1%. While gas central heating increased, this appears to have been at the expense of other non-oil central heating rather than oil.
f. Electricity customers rose from 755,000 in 2005 to 767,000 in 2010. These customers are not only households, as there are about 11,000 multiple meters, 7,000 second/holiday homes and 49,000 vacant properties.
g. The most recent figures on electricity customers published by the Utility Regulator of Northern Ireland imply a rate of house construction well in advance of what has been recorded in recent years.
h. The dominant source of domestic heating energy in Northern Ireland is oil, with gas and electricity accounting for only 11% of energy consumed. This compares with approaching 25% of all domestic energy. Renewables are currently a fairly minor component of domestic heating, although Phase 2 of the NI RHI is designed to support take up in the domestic sector and NI has overall targets of 4% renewable heat by 2015 and 10% by 2020.
i. Grid electricity generates about two-thirds more carbon dioxide per unit of energy than a direct burn.
j. A rough calculation suggests that if the number of gas customers increased by 12.7% (average annual growth rate over the period 2005-2010), the switch of about 18,400 customers from non-gas, non-electricity to gas would reduce carbon generation by 1.75%.
k. In Great Britain, home carbon dioxide emission by the top decile of households, by income, is double that of the lowest decile (rising to treble when the effects of travel are added in). The more rural an area, the greater the carbon dioxide emission with households in villages etc producing a quarter more carbon dioxide than urban households for home use (a fifth more overall)
l. Government energy policies deliver greatest benefits to urban and rural households, with actual disadvantage to households in the open country.
m. It is likely that higher income households are responsible for more carbon dioxide emission in Northern Ireland, just as in Great Britain, This is reinforced by the more rural nature of Northern Ireland, with lower incomes in the rural west, where natural gas is for the most part unavailable and oil is the fuel used, with higher levels of carbon dioxide emission.
n. The likelihood is that carbon policy and taxation work to the disadvantage of Northern Ireland. The interaction of the government policies works to the disadvantage of dispersed rural populations (not villages) and Northern Ireland has such a dispersed rural population. The Northern Ireland commitment to rural-proofing policies, if carried out robustly, might well mitigate against the adoption of such policies, to the extent that Northern Ireland has any say in the matter
o. The use of renewable energy is not quite the same as saving of carbon emissions. Natural gas is a low carbon emitter, by comparison with oil, coal or peat. Consequently, a switch from oil or solid fuel to gas, assuming that consumption of renewables remains constant, produces an increase in the percentage of carbon emission due to renewable sources, rather than an increase in percentage of energy due to renewable sources.
p. Designs with a view to maximising passive solar gain can secure 15-30% heating from this source. The effectiveness of this is very much influenced by orientation. Many single new properties in the country have in fact replaced an older property that has been subsequently abandoned, which may be regarded as extreme retrofitting. Oil is viewed as the traditional energy source.

7 SAP RATING

7.1 It is worth considering the SAP (Standard Assessment Procedure) in greater detail. SAP is calculated using: floor area; height; area of doors, windows and walls; storeys; structure, thickness and conductivity of materials of construction; thermal bridges; roof pitch; building alignment; chimneys, flues, vents and flueless gas fires; ventilation systems; heating system; hot water use and water heating system; overshading and local terrain. Modifying any of these will change the SAP.

7.2 The degree of overshading and the nature of the local terrain are not amenable to modification, and in practice, neither is building alignment. All the other components can be adjusted, at a cost that depends on the extent of the work done, which may be quite limited or very considerable.

7.3 SAP notes the possibility of lower cost improvement measures such as cylinder thermostats, heating controls, low energy lights, draught-proofing, and insulation of loft or cavity wall. Higher cost measures include boiler and heater upgrades, particularly using biomass. There are also further measures of varying cost, such as solar water heating, double and secondary glazing, solid wall insulation, condensing oil or gas boilers, photovoltaic measures and wind turbines.

7.4 SAP calculations assume a single standard UK-relevant latitude, climate and fuel cost, in order to compare properties on an equal footing. It is arguable that in practice, this is not particularly relevant to the needs of the household living in the property[14]. Fuel poverty data corrects to a certain extent for the effects of actual latitude, climate and fuel cost, but then introduces the confounding factor of household income. Table 7.1 shows that there is some variation in SAP (2001) rating by English region, from about 48.7 in the South West and Midlands to 53.3 in the North East, with the overall mean being 50.6. It is by no means clear whether the differences identified are sufficient to negate the variations in climate between the various regions.

Table 7.1 Variations in SAP (2001) by English Government Office Region

GOR	Mean SAP
North East	53.2
London	52.8
North West	51.4
Eastern	50.8
South East	50.5
Yorkshire & Humberside	49.9
East Midlands	48.8
West Midlands	48.8
South West	48.7
England	50.6

Source: BRE (2005)

[14] It is generally recognised that clothing suited to a summer day on Brighton beach would not suffice for a winter day in the Cheviots. The corresponding truth for housing (namely that any house built to standard specifications will give less comfort/more cost in a colder/more expensive location) is obscured by the use of SAP ratings which assess the performance of houses in a purely notional location.

7.5 Table 7.2 based on Wilkinson (2006) shows the alternative National Home Energy Rating (NHER), which takes account of climatic variation, for a house with SAP rating of 70 in the various regions of Great Britain, together with the estimated fuel costs (differences are smaller for higher SAP ratings and greater for lower SAP ratings). The regions are grouped into similar bands by Wilkinson (England) and the current author (Scotland), suggesting six bandings. Indexing the NHER to South West =100 suggests that there is a considerable decline in the comfort/cheapness afforded by a SAP70 house as one passes from Lands End to John O'Groats. On a climatic basis, Northern Ireland might be reasonably placed in Banding 4 (North West England to Highlands & Western Isles). The intra-regional variation within Northern Ireland would be equivalent to about half the inter-regional variation of Great Britain.

Table 7.2 NHER Rating, Heating cost and Band for SAP 2005 rating 70 house by GB region

Region	National Home Energy Rating	£	Band	Index of NHER (South West = 100)
South West	8.5	570	1	100.0
Home Counties	8.0	619	2	94.1
Southern	8.1	607	2	95.3
Severn Valley	8.0	620	2	94.1
Central Wales	7.9	625	2	92.9
South East	7.7	643	3	90.6
Midlands	7.7	648	3	90.6
West Pennines	7.6	653	3	89.4
East Pennines	7.7	645	3	90.6
East Anglia	7.7	642	3	90.6
North West England	7.4	672	4	87.1
Borders (England)	7.3	701	4	85.9
North East	7.2	695	4	84.7
Borders Scotland	7.1	703	[4]	83.5
South West Scotland	7.4	672	[4]	87.1
West Scotland	7.3	684	[4]	85.9
East Scotland	7.1	703	[4]	83.5
North East Scotland	6.8	735	[5]	80.0
Highlands	7.0	710	[5]	82.4
Western Isles	7.1	707	[4]	83.5
Orkney	6.8	734	[5]	80.0
Shetland	6.4	774	[6]	75.3

Source: Wilkinson using NHER Evaluator 4.1
NHER scale runs 0-10, SAP rating runs 1-100
[] Estimated by present author

7.6 Table 7.3 shows the recommended and minimum SAP ratings for the various location bands (Wilkinson, 2006). From this, it would seem that appropriate values for Northern Ireland would be 78 and 64 respectively, suggesting a need for energy efficiency perhaps 15-25% greater than in the South West of England in order to maintain the same standard of comfort and cost. An ideal target SAP rating might be 85 (mid-point of Energy Performance Certificate Band B).

Table 7.3 Recommended and Minimum SAP 2005 Rating

Location Band	1 South West	2 South	3 Midlands	4 North
Recommended SAP	66	71	74	78
Minimum SAP	51	56	59	64

Source: Wilkinson

7.7 Later work by Wilkinson (2007) suggests that "The climate in Northern Ireland (in terms of external temperatures and solar gains) is similar to The Midlands region of England" but quotes no figures. Given that Northern Ireland lies considerably to the north of the Midlands, and has a heating degree-days requirement amounting to 98% of Northwest England and 3.7% higher than the Midlands (Liddell, Morris, McKenzie & Rae, 2011), it is by no means clear that this position could be sustained. Nevertheless, on grounds of differentials in fuel pricing alone, Wilkinson suggests a minimum SAP of 80 and a recommended target of 93 for Northern Ireland. This would suggest that the proposed limit (64 and 78) is conservative.

7.8 Boardman (2010, p151) refers to a proposed SAP rating target of 80 for improved housing in England. On the assumption that this would relate to the midpoint between Bands 2 and 3, comparable regional targets for the North would be a minimum SAP of 71 and a recommended target SAP of 86 (see Table 7.4). Again, the proposed Northern Ireland limits appear conservative.

Table 7.4 Alternative Recommended and Minimum SAP 2005 Rating

Location Band	1 South West	2 South	3 Midlands	4 North
Recommended SAP	73	78	82	86
Minimum SAP	56	62	65	71

Source: Wilkinson and Boardman

7.9 Table 7.5 shows that in the period 2001-2011, social housing remained substantially better than private sector property, whether rented or owner-occupied, despite the transfer of properties from the social to the private sector. Its SAP rating on average exceeded the recommended level, which was not the case for the private sector. Detached houses and bungalows had noticeably lower SAP ratings than terraced and semi-detached houses.

Table 7.5 SAP Ratings

Average SAP Rating	**2001**	**2006**	**2009**	**2011**
Average SAP Rating By Dwelling Tenure				
Owner Occupied	46.07	52.55	56.10	59.93
NIHE	56.59	62.20	*	*
Housing Associations	65.99	68.20	*	*
Social Housing	*	*	63.44	67.79
Private Rented & Other (including tied)	42.79	52.97	55.34	59.17
All Dwellings	**47.84**	**53.89**	**56.65**	**59.63**
Average SAP Rating By Dwelling Type				
Bungalow	42.14	47.49	51.93	53.85
Terraced	52.32	57.27	58.40	61.84
Semi – Detached	46.80	53.84	57.65	60.62
Detached	42.71	51.43	54.60	57.49
Flat	61.66	64.05	65.04	69.24
All Dwellings	**47.84**	**53.89**	**56.65**	**59.63**

Source: Table 2.2 Housing Statistics

NB SAP Rating system was changed for 2006 onwards

7.10 Some technical issues in the SAP bandings are:

a) Age bandings throughout the UK are based on introduction of new building regulations + 1 year, after 1950, and are the same prior to that date. This is a considerable simplification. The pre -1951 assumption is of change at the same date, and the post-1950 assumption is of change driven by regulation. Neither assumption is true. It is well established that cavity wall construction reached Ireland quite late, compared with Great Britain, and regulation tends to follow change. The delays in the Northern Ireland legislative process do not prove that changes have yet to arrive. It may be noted that NI SAP software does use significantly different age band to those in GB software specifically aimed at tackling the differing periods of introduction of building control legislation.

b) The model assumes that for older buildings, the U-value for stone construction materials in Northern Ireland is the same as in England & Wales but worse than Scotland. It is unclear whether this is a function of the thickness of the material used or due to its thermal property (soft limestone and granite have notably different thermal conductivity), and it is also unclear what the evidence is for the aggregated difference. No allowance is made for the variation in construction materials and methods within England, Wales and Northern Ireland.

c) SAP ratings are affected by changes in the UK relativities in energy prices but the NI change may not be the same.

7.11 In summary, therefore:

a. SAP (Standard Assessment Procedure) is calculated using a wide range of properties. Modifying any of these will change the SAP. Most components of the measure can be adjusted, at a cost that depends on the extent of the work done, which may be quite limited or very considerable.
b. SAP differentiates between lower and higher cost improvement measures
c. SAP calculations assume a single standard UK-relevant latitude, climate and fuel cost, in order to compare properties on an equal footing. It is arguable that in practice, this is not particularly relevant to the needs of the household living in the property
d. There is a considerable decline in the comfort/cheapness afforded by a SAP70 house as one passes from Lands End to John O'Groats. On a climatic basis, Northern Ireland might be reasonably placed in Banding 4 (North West to Highlands & Western Isles). The intra-regional variation within Northern Ireland would be equivalent to about half the inter-regional variation of Great Britain.
e. Appropriate recommended and minimum SAP ratings for Northern Ireland would be 78 and 64 respectively, suggesting a need for energy efficiency perhaps 15-25% greater than in the South West of England in order to maintain the same standard of comfort and cost. The ideal SAP rating might be 85. This is a conservative approach.
f. In the period 2001-2011, social housing In Northern Ireland remained substantially better than private sector property, whether rented or owner-occupied, despite the transfer of properties from the social to the private sector. Detached houses and bungalows had noticeably lower SAP ratings than terraced and semi-detached houses.

8 FUEL POVERTY

8.1 The Northern Ireland 2011 House Conditions Survey shows that of their estimate of 701,240 households in Northern Ireland[15], 42.2% suffer from fuel poverty. Table 8.1 shows that this varies from about 40% for owner occupied and social housing to 49% for private rented accommodation. For younger households, with or without children, 33-37% suffer fuel poverty, compared with 61% of older households (cf 62% in households where the household reference person is retired). Where the household reference person (FRP) is not working, fuel poverty is twice as common as where the FRP is working (55% compared with 27%). Fuel poverty is greatest in bungalows (51%) and isolated rural settlements (50%). Pre-war properties (54-69%) are most likely to exhibit fuel poverty, compared with post-1980 properties (27%). Where household income is below £10,000 per annum, fuel poverty is 79%, compared with 5% for households where the income is £30,000 or more.

Table 8.1 Northern Ireland Fuel Poverty 2011

Households	701,240				
Overall % Fuel Poor	42.2				
Tenure	**% Fuel Poor**	**Household type**	**% Fuel Poor**	**Employment of HRP**	**% Fuel Poor**
Owner Occupied	40.6	Adult	36.8	Working	27.4
Private rented & Other	49.1	With children	32.9	Not working	55.4
Social Housing	39.7	Older	60.8	Retired	61.7
Building type	**% Fuel Poor**	**Age of HRP**	**% Fuel Poor**	**Location**	**% Fuel Poor**
Bungalow	51.3	17-24	44.2	Belfast Metropolitan Area	40.7
Terrace House	45.9	25-39	25.6	District or Other Town	41.6
Semi-detached House	39.7	40-59	38.9	Small Rural Settlement	39.0
Detached House	36.4	60-74	52.0	Isolated Rural settlement	50.2
Flat/Apartment	23.5	75 and over	66.3		
Age of Property	**% Fuel Poor**	**Household Income**	**% Fuel Poor**		
Pre 1919	68.7	Under 10,000	79.4		
1919-1944	53.6	10,000-14,999	63.8		
1945-1964	49.1	15,000-19,999	40.9		
1965-1980	48.4	20,000-29,999	18.6		
Post 1980	26.7	30,000 and over	5.4		
Source: 2011 Northern Ireland House Conditions Survey					

8.2 The Poverty and Social Exclusion UK Survey (2012) asks questions about heat usage and thermal comfort. Table 8.2 shows that Northern Ireland households were much more likely than Great Britain households to turn down their heating on grounds of cost, and find their homes too cold.

[15] Estimates of household numbers vary according to source and methodology

Table 8.2 Heat Usage and Thermal Comfort, Northern Ireland and Great Britain

Issue	Northern Ireland	Great Britain
Percentage of households turning heating off or down although it was too cold, because they could not afford fuel costs	46	35
Percentage of households finding the level of heat in their home a bit or much colder than they would have liked	41	34

Source: Preliminary results, Poverty & Social Exclusion UK Survey 2012

8.3 About 2,150 homes were interviewed (Liddell, Lagdon and Walker, in prep 2013) in areas identified as likely to have high levels of fuel poverty, using an Area-based Algorithm (ABA) About 18% of ABA houses are built pre-1945. Some 90% of the houses under ABA are Oil-fired, with a further 5% using Solid fuel (Coal). About 15% consider that the heating system heats their home too much, and 34% consider that the system heats it too little. Given that the ABA was intended to highlight houses with fuel poverty, and is judged to have been successful[16], this suggests for most occupants, fuel poverty manifests itself somewhat more as a financial problem rather than as a heating problem.34-36% of boilers using Coal, Oil and Other Fuels leave the house too cold, compared with 23% of Gas boilers. This is an issue of boiler age rather than fuel type.

8.4 Table 8.3 shows that 37% of those using natural gas have a boiler aged five years or less, compared with 12-13% for those using most other fuels and 8% of those using coal. Some of those burning coal may not have a boiler at all, of course. Table 8.4 shows the degree of thermal comfort enjoyed by households, with 21-25% (depending on whether they had a new boiler or not) of those using natural gas reporting that they were too cold. Households using other fuels with a new boiler are slightly colder (26%) whilst those using other fuels without a new boiler are considerably colder (36%). The odds of a household being too cold are 1.88 times greater for a household using a fuel other than natural gas without a new boiler than for a household using natural gas. It is not certain whether this is solely due to the age and type of the boiler, or whether properties have other thermal deficiencies associated with older and non-gas boilers.

Table 8.3 Age of boiler by Fuel Type

Main heating fuel	Age of boiler		Total
	0-5 years	Over 5 yrs/DK/NA	
Natural gas	37.2%	62.8%	78
Oil	12.6%	87.4%	1,908
Solid Fuel (Coal)	8.4%	91.6%	95
Other	11.6%	88.4%	43
All	13.3%	86.7%	2,124

Source: ABA database

Table 8.4 Thermal Comfort by Age of Boiler and Fuel Type

[16] For example, whilst the Northern Ireland Regional Fuel Poverty rate at the time of ABA was 42%, the ABA approach identified areas in NI which averaged 78% fuel poverty prevalence

Fuel Type	Age of Boiler	Thermal Comfort			Total
		Too Warm	About Right	Too Cold	
Natural Gas	0-5 years	13.8%	65.5%	20.7%	29
	Over 5 yrs/DK/NA	18.8%	56.2%	25.0%	48
All Other Fuel Types	0-5 years	15.0%	59.3%	25.6%	246
	Over 5 yrs/DK/NA	14.8%	49.5%	35.7%	1,769

Source: ABA database

8.5 These results show a lower level of thermal discomfort than reported by the Poverty and Social Exclusion survey UK for Northern Ireland, but the discrepancy is far smaller for those using fuels other than gas with old boilers (who form 85% of the sample).

8.6 Table 8.5 shows that there is a clear distinction between Belfast, where nearly a quarter of households in areas of the city believed to be most in fuel poverty have natural gas, and other districts, where the proportion is lower (8-16% in Larne, Carrickfergus and Newtownabbey, or 2% or less in the remaining fifteen districts participating in the project). The proportion of respondents in the category most likely to report cold (ie not using natural gas and no new boiler) varies from 72% in Belfast to 96% in Armagh, and apart from the four districts (Belfast, Larne, Carrickfergus and Newtownabbey) with substantial natural gas use, only Cookstown (78%) has less than 80% of respondents not using natural gas and having no new boiler.

8.7 Table 8.6 shows that the proportion of respondents, not using natural gas and having no new boiler, lies between 83% (Small Town) and 90% (Medium Town) in all settlement types except the Belfast Metropolitan Urban Area (71%). This tends to suggest that the focus of any intervention should lie outside the Belfast Metropolitan Urban Area.

8.8 Some 13% of respondents do not know how old their boiler is, and less than a quarter have a boiler known to be less than 10 years old. Less than a fifth know for sure that their boiler has been serviced in the last year. There is much use of payment in advance, with 53% pre-payment of electricity. Those with gas are 73% on pre-payment and 67% paying cash on delivery for oil. Some 45% of households report household income of under £12,000 (setting a fuel poverty limit on need expenditure at £12000).

8.9 Fuel poverty is estimated on the basis of the cost of the energy required by the current housing kit to heat accommodation of a household to a healthy temperature (as defined by the World Health Organisation i.e. 21^{o}C in the living room and 18^{o}C elsewhere).This is not the same as the cost of the energy actually used by the household, which may be more or less than the fuel poverty cost, depending on requirements and preferences of the household. It is thus entirely possible to take a household out of fuel poverty, without affecting its actual consumption at all. In fact, a household may even be enabled to increase consumption of energy, whilst holding the cost constant or affecting only a small saving (the rebound effect).

Table 8.5 Fuel Type and Boiler Age by District Council

Council	Fuel and Boiler Age			Total
	Natural Gas	Not Natural Gas (Boiler 5 years or less old)	Not Natural Gas (Boiler more than 5 years old/DK/NA)	
Armagh	1.4%	2.8%	95.8%	71
Ballymena	1.6%	12.8%	85.6%	125
Ballymoney	0.0%	12.8%	87.2%	125
Banbridge	0.8%	11.7%	87.5%	128
Belfast	23.4%	4.5%	72.1%	111
Carrickfergus	13.0%	8.9%	78.0%	123
Coleraine	0.0%	11.3%	88.7%	124
Cookstown	0.8%	21.6%	77.6%	125
Craigavon	2.0%	14.3%	83.7%	98
Dungannon	0.0%	11.6%	88.4%	121
Fermanagh	0.0%	12.1%	87.9%	124
Larne	8.3%	17.4%	74.4%	121
Limavady	0.0%	10.9%	89.1%	119
Moyle	0.0%	13.5%	86.5%	126
Newry and Mourne	0.0%	7.2%	92.8%	111
Newtownabbey	16.0%	6.4%	77.6%	125
Omagh	0.0%	10.6%	89.4%	123
Strabane	0.0%	19.2%	80.8%	125

Source: ABA database

Table 8.6 Fuel Type and Boiler Age by Settlement Type

Settlement type	Fuel and Boiler Age			Total
	Natural Gas	Not Natural Gas (Boiler 5 years or less old)	Not Natural Gas (Boiler more than 5 years old/DK/NA)	
Belfast Metropolitan Urban Area	22.7%	6.0%	71.3%	251
Large Town	5.1%	9.5%	85.4%	274
Medium Town	1.1%	8.7%	90.2%	92
Small Town	0.0%	17.4%	82.6%	46
Intermediate Settlement	0.7%	12.4%	86.9%	137
Village	0.0%	10.2%	89.8%	205
Small Village, Hamlet and Open Countryside	0.1%	14.7%	85.2%	1,017

Source: ABA database

8.10 In summary, therefore:

a. In 2011, some 42.2% of households suffered from fuel poverty. The level was higher in private rented accommodation, older and retired households, non-working households, bungalows, isolated rural settlements, pre-war properties and low income households.
b. Northern Ireland households are much more likely than Great Britain households to turn down their heating on grounds of cost, and find their homes too cold.
c. Households using natural gas were less likely to report cold, and households using other fuels without a new boiler were most likely to report cold.
d. Households using fuels other than natural gas without a new boiler are least common in the Belfast Metropolitan Urban Area (especially Belfast, Carrickfergus and North Down).
e. Many households do not know the age of their boiler, or know that it is less than 10 years old. Knowledge of the service record of boilers is not good. There is much use of pre-payment and many household incomes are very low.

9 RURAL AREAS, POOR HOUSING AND POVERTY

9.1 Table 9.1 shows that the proportion of dispersed housing[17] in Northern Ireland is about 37%, but this proportion rises from 7% in the Belfast Metropolitan area to 58% in villages. In small villages, hamlets and open countryside, the proportion is 97%. Dispersed housing can occur in high status areas of a settlement, but is more usually due to peripherality, where a small area includes some open countryside beyond the bounds of the settlement, yielding an average result for the overall area that is typical of neither settlement type.

Table 9.1 Proportions of small areas with dispersed housing by settlement type

CLASSIFICATION BAND	Distance Measure of Housing Dispersal		Total
	Not Distant	Distant	
BELFAST METROPOLITAN URBAN AREA	92.6%	7.4%	1668
DERRY URBAN AREA	89.3%	10.7%	205
LARGE TOWN	83.1%	16.9%	633
MEDIUM TOWN	70.5%	29.5%	261
SMALL TOWN	76.8%	23.2%	284
INTERMEDIATE SETTLEMENT	61.4%	38.6%	166
VILLAGE	42.0%	58.0%	188
SMALL VILLAGE HAMLET AND OPEN COUNTRYSIDE	3.3%	96.7%	1132
Total	63.3%	36.7%	4537

Source: Own calculations
Distant: mean distance of houses in the areas is greater than 100 metres

9.2 Table 9.2 shows that the average distance between households is 50-70 metres in non-sparse areas within settlements, compared with 480 metres in open countryside. About 75% of non-sparse areas of Belfast Metropolitan Urban Area have access to natural gas, compared with less than 2% of areas in the open countryside. It is estimated that the proportion of households in fuel poverty in sparse areas is 47%, compared with 39% in non-sparse areas. The proportion is 36-46% for non-sparse settlement areas and 35-44% for sparse settlement areas (ie virtually the same). For the open countryside, it is 51% and for small villages and hamlets, 56%. This suggests that the most rural areas are most subject to fuel poverty. The results are very similar to those of the House Conditions Survey, suggesting that the small area estimates are broadly accurate.

[17] Average inter-house distance (metres) is calculated by

$$2 \times \sqrt{(\text{area in hectares} \times 10000 / \text{households})}$$

Households are deemed to be distant when the average distance between them is greater than 100 metres, since at this distance, unaided oral communication is severely impeded.

Table 9.2 Household separation, fuel poverty and gas access by settlement type

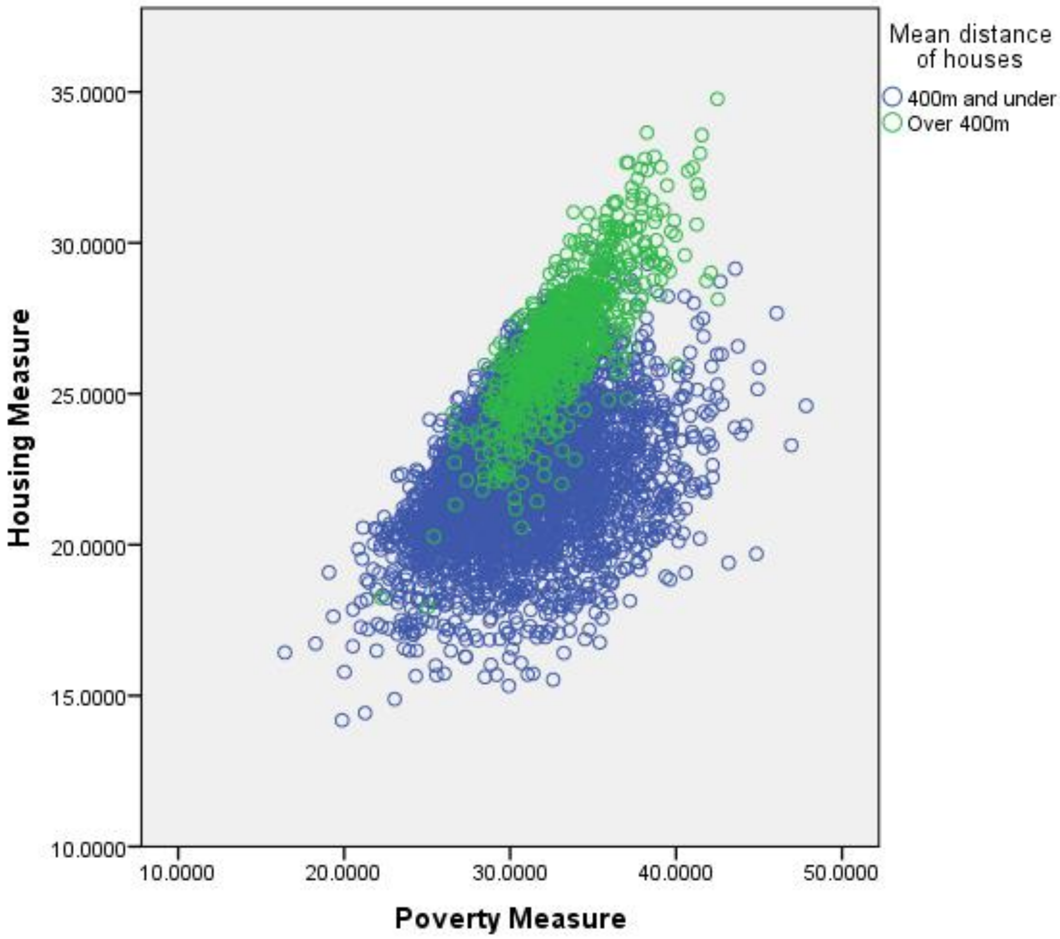
CLASSIFICATIONBANDNAME	Average inter-household distance (m)		Percent Likely Fuel Poor		Gas access (fraction of households)	
	Not Distant	Distant	Not Distant	Distant	Not Distant	Distant
BELFAST METROPOLITAN URBAN AREA	47.2	161.4	37.4	39.7	0.740	0.455
DERRY URBAN AREA	53.3	164.5	36.3	35.2	0.241	0.038
LARGE TOWN	60.0	159.1	40.2	38.0	0.296	0.180
MEDIUM TOWN	63.3	157.9	42.5	40.1	0.088	0.061
SMALL TOWN	62.1	203.7	38.3	38.6	0.133	0.069
INTERMEDIATE SETTLEMENT	66.7	184.0	44.3	43.9	0.010	0.011
VILLAGE	67.8	231.9	45.6	44.2	0.004	0.016
SMALL VILLAGE HAMLET AND OPEN COUNTRYSIDE	77.3	481.1	55.9	51.1	0.209	0.018
Total	53.8	372.0	39.0	47.2	0.480	0.066

Source: Own calculations

Distant: Mean distance of households is greater than 100 metres

Fuel Poverty: an estimate of fuel poverty in small areas in 2011 is derived from the ratio of the housing component of the ABA measure of need (a surrogate for energy costs) to the poverty component (a surrogate for income) for each area, applied to the number of households in that area. This measure is used to distribute the 2011 HCS Northern Ireland estimate of households in fuel poverty between small areas. Over-allocations (ie where estimated number in fuel poverty exceeds the number of local households) are reduced appropriately and the surplus reallocated to small areas with less than 100% fuel poverty

Graph 9.1 Housing and Poverty Measures in Small Areas by Housing Dispersal



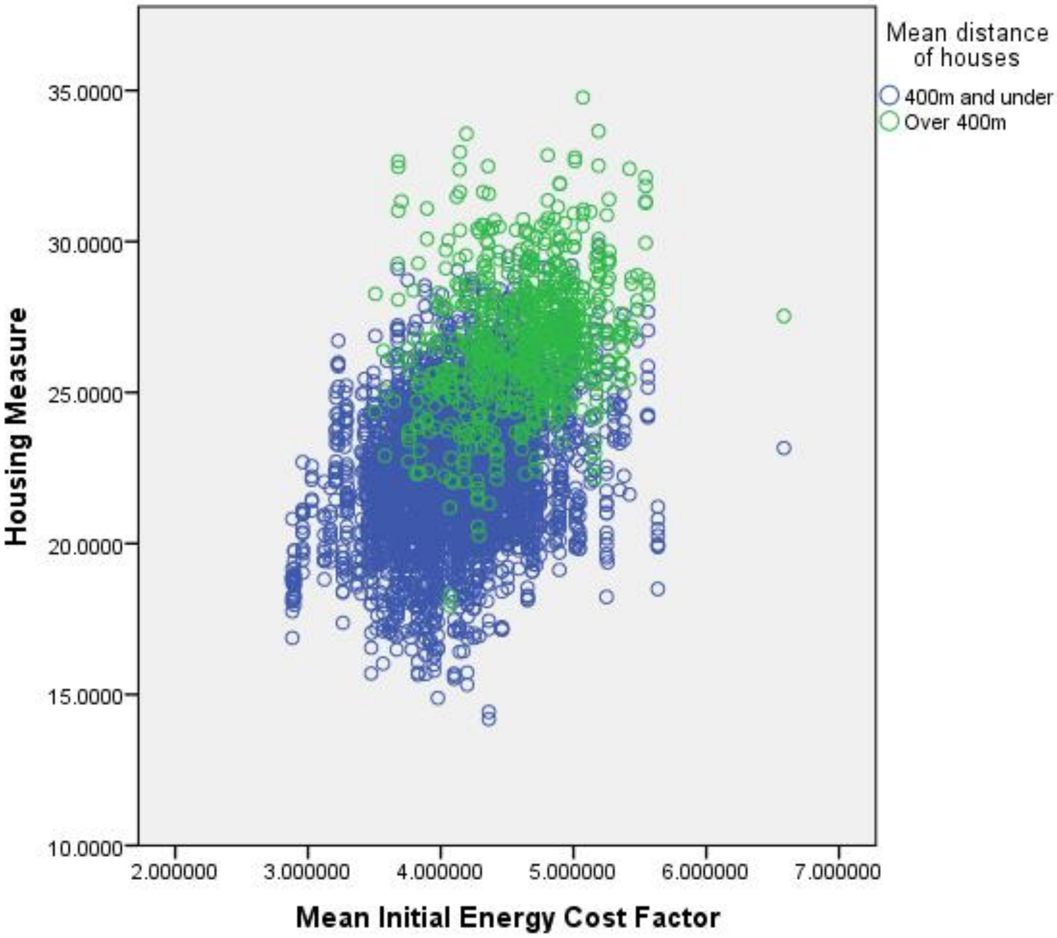
Source: Walker, McKenzie, Liddell & Morris (2012)
Housing Measure assesses relative energy costs of Small Areas, taking account of housing (size, age and type) and location (access to natural gas, oil prices, climate)
Poverty Measure assesses relative incomes of Small Areas, taking account of poverty (Family Resources Survey) and benefit uptake

9.3 Walker, McKenzie, Liddell and Morris (2012) identify the level of problematic housing and of poverty by census output areas and Graph 9.1 shows the results, modified to the rather less numerous small areas used for output from the 2011 Census of Population and distinguishing between rural areas and others. Although poor housing and poverty tend to be associated, the link is rather stronger in rural areas.

9.4 Graph 9.2 examines the relationship of poor housing and high energy cost factor among houses receiving help through Warm Homes[18]. Rural areas tend to have more poor housing and higher energy costs.

[18] Warm Homes is a government funded scheme for assisting lower income households in properties in need of thermal improvement

Graph 9.2 Housing Measure and mean Energy Cost Factor of Warm Homes properties in Small Areas by Housing Dispersal



Source: Source: Walker, McKenzie, Liddell & Morris (2012)

Housing Measure assesses relative energy costs of Small Areas, taking account of housing (size, age and type) and location (access to natural gas, oil prices, climate)

Poverty Measure assesses relative incomes of Small Areas, taking account of poverty (Family Resources Survey) and benefit uptake

9.5 Table 9.3 shows that the areas with low levels of problematic housing are rarely sparsely inhabited rural areas, whether poverty is low (2% sparse rural) or high (1% sparse rural), with low being defined as less than median for both poverty and problematic housing. Areas with high problematic housing and low poverty are 17% sparse rural, and areas with high problematic housing and high poverty are 39% sparse rural.

Table 9.3 Housing Sparsity by Housing and Poverty Measure for Small Areas

Housing & Poverty Measure	Market Segment	Settlements and densely inhabited open country (mean distance of houses 400m and under)	Sparsely inhabited open country (mean distance of households over 400m)	Total
Better Housing, Higher Income	No obvious need for measures	98.2%	1.8%	228,577
Better Housing, Lower Income	Reasonable standards	99.2%	0.8%	123,024
Poorer Housing, Higher Income	Able to pay	83.1%	16.9%	122,973
Poorer Housing, Lower Income	Needing subsidy	61.1%	38.9%	228,701
All	All	588,489	114,786	703,275

Source: Source: Walker, McKenzie, Liddell & Morris (2012)
Higher Income, better housing: below median level of measure
Lower Income, poorer housing: median and above level of measure
Housing Measure assesses relative energy costs of Small Areas, taking account of housing (size, age and type) and location (access to natural gas, oil prices, climate)
Poverty Measure assesses relative incomes of Small Areas, taking account of poverty (Family Resources Survey) and benefit uptake (ABA database)

9.6 Table 9.4 shows that areas with high levels of problematic housing have predominately detached properties (51-55% cf 12-28% elsewhere). Social housing is most important in areas with relatively good housing but high poverty (35%), compared with 4% for areas with poor housing but low poverty and 1-13% for other areas. Warm Homes work in areas with high levels of problematic housing typically help properties which have energy cost factors (4.34 – 4.37), which are about 12% higher than the properties helped in areas with lower levels of problematic housing, but high levels of poverty.

9.7 This strongly suggests that any policy targeting fuel poverty should be targeting rural areas in order to achieve success, and in particular, it should be targeting sparsely inhabited rural areas.

Table 9.4 Detached Properties, Social Housing and Warm Homes Initial Energy Cost Factor by Housing and Poverty Measure for Small Areas

Housing & Poverty Measure	Market Segment	Percent Detached Properties	Percent Social Housing	Warm Homes Initial ECF
Better Housing, Higher Income	No obvious need for measures	28.2	12.6	4.12
Better Housing, Lower Income	Reasonable standards	12.1	34.8	3.90
Poorer Housing, Higher Income	Able to pay	55.2	4.0	4.34
Poorer Housing, Lower Income	Needing subsidy	51.2	12.4	4.37
Total	All	37.6	14.9	4.20

Source: Source: Walker, McKenzie, Liddell & Morris (2012)

Higher Income, better housing: below median level of measure

Lower Income, poorer housing: median and above level of measure

Housing Measure assesses relative energy costs of Small Areas, taking account of housing (size, age and type) and location (access to natural gas, oil prices, climate)

Poverty Measure assesses relative incomes of Small Areas, taking account of poverty (Family Resources Survey) and benefit uptake (ABA database)

ECF: Energy Cost Factor. This is the BRE-based estimate of actual Energy Costs, prior to application of the scaling used to convert into SAP ratings

9.8 In summary, therefore:

a. The proportion of dispersed housing in Northern Ireland is about 37%, but this proportion rises from 7% in the Belfast Metropolitan area to 58% in villages. In small villages, hamlets and open countryside, the proportion is 97%.
b. The average distance between households is 50-70 metres in non-sparse areas within settlements, compared with 480 metres in open countryside. About 75% of non-sparse areas of Belfast Metropolitan Urban Area have access to natural gas, compared with less than 2% of areas in the open countryside. It is estimated that the proportion of households in fuel poverty in sparse areas is 47%, compared with 39% in non-sparse areas.
c. The proportion is 36-46% for non-sparse settlement areas and 35-44% for sparse settlement areas (ie virtually the same). For the open countryside, it is 51% and for small villages and hamlets, 56%. This suggests that the most rural areas are most subject to fuel poverty.
d. Although poor housing and poverty tend to be associated, the link is rather stronger in rural areas. Rural areas tend to have more poor housing and higher energy costs. Areas with low levels of problematic housing are rarely rural, whether poverty is low (2% rural) or high (1% rural), with low being defined as less than median for both poverty and problematic housing. Areas with high problematic housing and low poverty are 17% rural, and areas with high problematic housing and high poverty are 39% rural.
e. Areas with high levels of problematic housing have predominately detached properties (51-55% cf 12-28% elsewhere). Social housing is important in areas with relatively good housing but high poverty (35%), compared with 4% for areas with poor housing but low poverty and 1-13% for other areas. Warm Homes work in areas with high levels of problematic housing typically help properties which have energy cost factors (4.34 – 4.37), which are about 12% higher than the properties helped in areas with lower levels of problematic housing, but high levels of poverty.
f. This strongly suggests that any policy targeting fuel poverty should be targeting rural areas in order to achieve success, and in particular, it should be targeting small villages, hamlets and open countryside.

10 WARM HOMES SCHEME

10.1 Warm Homes is a government funded scheme for assisting lower income households in properties in need of thermal improvement. A considerable volume of data as supplied by scheme managers is available to University of Ulster on the work undertaken in recent years for the Warm Homes scheme. It is possible to estimate the local (ward) average for SAP improvement, number of improvements undertaken and cost of work. There is no strong relationship between SAP improvement and cost, but the more improvements undertaken, the greater the cost. Annex 4 contains details of the data supplied. It shows that Minor and Major retrofits (£1,800 or more) can be distinguished.

10.2 The Warm Homes data as supplied was initially analysed at Census Output Area to produce local averages. This was necessary because the data supplied relating to work on a single house differed according to time period. Table 10.1 shows that the Northern Ireland average cost in recent years is £1490, and an average SAP improvement of 9.8 points was recorded. There is a considerable variation, however, between Belfast Metropolitan Urban Area (cost of £1216, improvement of 10.6 SAP points – ratio of £115 per SAP point gained) and small villages, hamlets and open countryside (cost £1807, improvement of 8.7 SAP Points – ratio of £208 per SAP point gained). This suggests that improving the housing stock in the most rural of areas is likely to be about 80% more expensive than improving stock in Belfast (or 37% more expensive than the Northern Ireland average). Numbers in fuel poverty by local area are estimated (see note to Table 9.2).

Table 10.1 Warm Homes Works and Cost of Intervention

CLASSIFICATION BAND	Average Initial SAP	Average SAP Improvement	Average Cost (£)	Estimated Number In Fuel Poverty	Estimated Cost of intervention
BELFAST METROPOLITAN URBAN AREA	45	10.6	1216	92,807	113,683,778
DERRY URBAN AREA	48	7.4	1366	12,463	16,422,242
LARGE TOWN	46	9.6	1485	37,997	57,185,936
MEDIUM TOWN	46	9.4	1766	17,640	31,557,678
SMALL TOWN	45	9.6	1490	17,121	25,411,351
INTERMEDIATE SETTLEMENT	43	9.9	1632	12,247	19,934,763
VILLAGE	44	8.7	1658	13,715	22,839,465
SMALL VILLAGE HAMLET AND OPEN COUNTRYSIDE	40	9.6	1807	92,790	167,290,178
Northern Ireland	44	9.8	1490	296,780	454,325,391

Source: Warm Homes and own estimate of local Fuel Poverty

10.3 Table 10.2 shows the costs of Warm Homes measures by tenure and intervention type. While insulation measures have a similar cost in both owner-occupied and private rented sector, rising from about £500 in 2006-07 to £670 in 2011-12 (33% over 5 years) the cost of heating measures installed has diverged by sector. The cost in 2006-07 was £3,840 in both sectors. Whilst the value of work on private rented properties remained the same, it increased by 31% for owner-occupied to £5,040 in 2011-12.

Table 10.2 Warm Homes Costs

£ per intervention	2006/2007	2007/2008	2008/2009	2009/2010	2010/2011	2011/2012	Average
Owner Occupied							
Insulation Measures	503.28	474.91	553.03	544.93	540.96	668.62	547.62
Heating Measures	3840.35	4039.04	3962.07	3847.41	4232.74	5040.97	4160.43
Private Rented							
Insulation Measures	502.74	436.10	589.27	518.09	512.34	670.04	538.10
Heating Measures	3839.70	4133.96	3965.68	3879.03	3883.16	3805.83	3917.89

Source: Table 2.3 Housing Statistics

10.4 Applying the local cost of intervention to the estimated local numbers in fuel poverty[19] suggests that the total cost of a retrofit for every house containing a fuel poor household, at recent prices, would be about £454 million for Northern Ireland as a whole. It is an estimate broadly in line with the estimate derived from the Cambridge Econometric Service data (see paragraphs 14.1 onwards), allowing for the fact that the costs are cash prices over a number of years. This level of expenditure would probably not be sufficient to achieve a target SAP rating of 78 for the units improved.

10.5 Applying these results to the CES estimate of £1,800 per improvement (2008 prices), it would be reasonable to assume expenditure of £1350 per unit in Belfast and £2450 in small villages, hamlets and open countryside. On Washan's more substantial grant of £6,500, these prices would be £5305 and £7883, with a total cost of £1.72 billion to cover 87% of properties with a household in fuel poverty.

10.6 This higher figure seems a more plausible cost, if it is assumed that the objective is to improve units to a target SAP rating of 78, and further assumed that the cost per SAP unit gained remains constant. If all properties (including those occupied by the fuel poor) in need of improvement have a SAP in the range 40-50, as was the case historically (see Table 10.3), the total cost of improvement is in the neighbourhood of £2 billion. Improvement to a target SAP rating of 80 (Boardman target for England) would be 5.8% more expensive, and to SAP rating 85 (NI optimum), it would be 20.2% more expensive.

10.7 Table 10.4 shows that on the basis of the 2009 House Conditions Survey, improving all properties to a SAP rating of 78 at a cost of £152 per point of SAP improvement, would cost £2.4 billion. About 10% of this would be in respect of social housing.

[19] Sum of local intervention numbers x local cost does not equal NI intervention number x NI cost

Table 10.3 Cost of improvement of Fuel Poor dwellings to SAP level 78

CLASSIFICATION BAND	Initial SAP	SAP Improvement	Average Cost (£)	Cost per unit to improve to SAP 78	Cost per unit adjusted to mean £6,500	Estimated Cost of intervention (£)
BELFAST METROPOLITAN URBAN AREA	45	10.6	1216	3,786	4,760	441,770,418
DERRY URBAN AREA	48	7.4	1366	5,538	6,963	86,783,483
LARGE TOWN	46	9.6	1485	4,950	6,224	236,498,698
MEDIUM TOWN	46	9.4	1766	6,012	7,559	133,347,738
SMALL TOWN	45	9.6	1490	5,122	6,440	110,263,646
INTERMEDIATE SETTLEMENT	43	9.9	1632	5,770	7,255	88,849,905
VILLAGE	44	8.7	1658	6,480	8,147	111,741,436
SMALL VILLAGE HAMLET AND OPEN COUNTRYSIDE	40	9.6	1807	7,153	8,994	834,537,656
Northern Ireland	44	9.8	1490	5,169	6,500	2,043,792,980

Source: Warm Homes

Table 10.4 Cost of improvement of all properties (2009) to SAP 78

Tenure	Mean SAP Rating	Mean SAP improvement	Properties	Total Improvement Cost (£)
Owner Occupied	56	22	456,734	1,515,484,293
Private Rented and Others	57	22	120,466	408,257,029
Social Housing	63	15	102,197	248,117,669
Vacant	47	31	42,051	204,136,119
Total	57	21	721,449	2,375,995,110

Source: House Conditions Survey 2009, assuming a cost of £152 per point of SAP improvement

10.8 Annex 5 shows that about 42% of the variance of average local cost of works under Warm Homes can be explained by thirteen local variables found to be statistically significant. The model suggests a basic cost of £3,800, which experiences substantial reductions for units in Belfast, Derry and in areas with higher levels of gas uptake, oil price, social housing, owner occupation, room occupancy (households in mid life cycle, smaller houses) and population density (urban vs rural). Spending is greater for units in those areas with higher levels of detached housing, terraced housing, room numbers (bigger houses), older people and annual degree-days (colder areas).

10.9 This is intuitively plausible, and suggests that the areas of spending are being broadly governed by factors that are appropriate. It can afford no guarantee concerning the impact on individuals, since it is an area-based analysis. The individuals who have been helped within an area are not necessarily those in most need, but ongoing work at the University of Ulster is demonstrating that these can be readily distinguished and prioritised..

10.10 Annex 6 shows the results of a further, simpler and slightly more powerful stepwise regression seeking to explain the average cost of Warm Homes work in small areas of Northern Ireland. It is possible to explain 45% of the variance in costs using just six statistically significant variables. These are, in descending order of importance, the proportion of boilers installed by NIHE which are gas burners, density of settlement (average inter-house distance), energy efficiency (average initial energy cost factor of properties improved under Warm Homes), average oil price, poverty (proportion of poor households) and climate (average annual degree days).

10.11 Low energy efficiency (ie high energy cost), low density of settlement (ie greater distance between houses) and high poverty are associated with higher costs of work. Greater availability and use of gas boilers, higher oil prices and colder climate (ie higher number of degree-days) are associated with cheaper work.

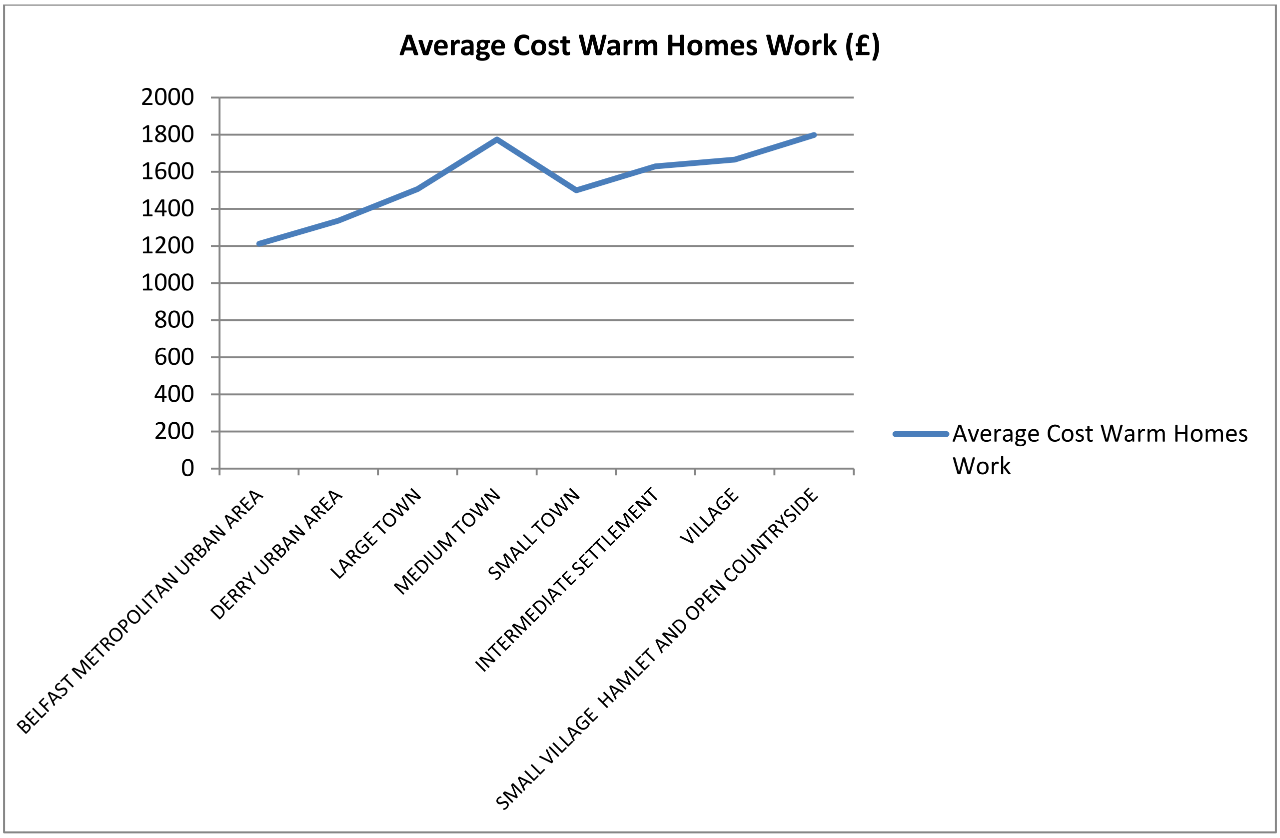
10.12 Table 10.5 and Graphs 10.1-10.3 show that the lowest cost of work is found in the Belfast Metropolitan Urban Area, where gas is available, settlement is dense and poverty is low, while energy efficiency is good, oil price is high and climate is warm. Highest costs are in small villages, hamlets and open country, where gas is not available and settlement is sparse (though poverty is low). Energy efficiency is poor, oil price is low and climate is cold. There is therefore a strong geographical link to the costs being incurred, with poor housing and absence of gas in cool rural areas.

Table 10.5 Average value of significant explanatory variables for the cost of Warm Homes work, analysed by settlement type

CLASSIFICATION BAND	Average Cost Warm Homes Work	Boiler Gas Proportion (NIHE installations)	Average inter-house distance	Initial Energy Cost Factor	Oil price	Poverty	Annual Degree Days
BELFAST METROPOLITAN URBAN AREA	1211.25	0.45	56.78	4.09	202.96	17.29	2086.90
DERRY URBAN AREA	1334.95	0.01	68.21	3.82	191.56	20.45	2147.16
LARGE TOWN	1506.34	0.09	79.23	4.01	200.34	18.07	2116.23
MEDIUM TOWN	1773.61	0.00	92.63	4.06	197.90	18.23	2135.01
SMALL TOWN	1500.04	0.03	99.26	4.15	199.86	16.88	2112.75
INTERMEDIATE SETTLEMENT	1628.84	0.00	117.76	4.25	199.79	16.08	2167.14
VILLAGE	1664.58	0.00	171.11	4.26	199.49	17.47	2157.86
SMALL VILLAGE HAMLET AND OPEN COUNTRYSIDE	1797.61	0.01	466.87	4.57	198.91	15.33	2221.18
Total	1496.62	0.18	178.12	4.20	200.22	17.04	2139.18

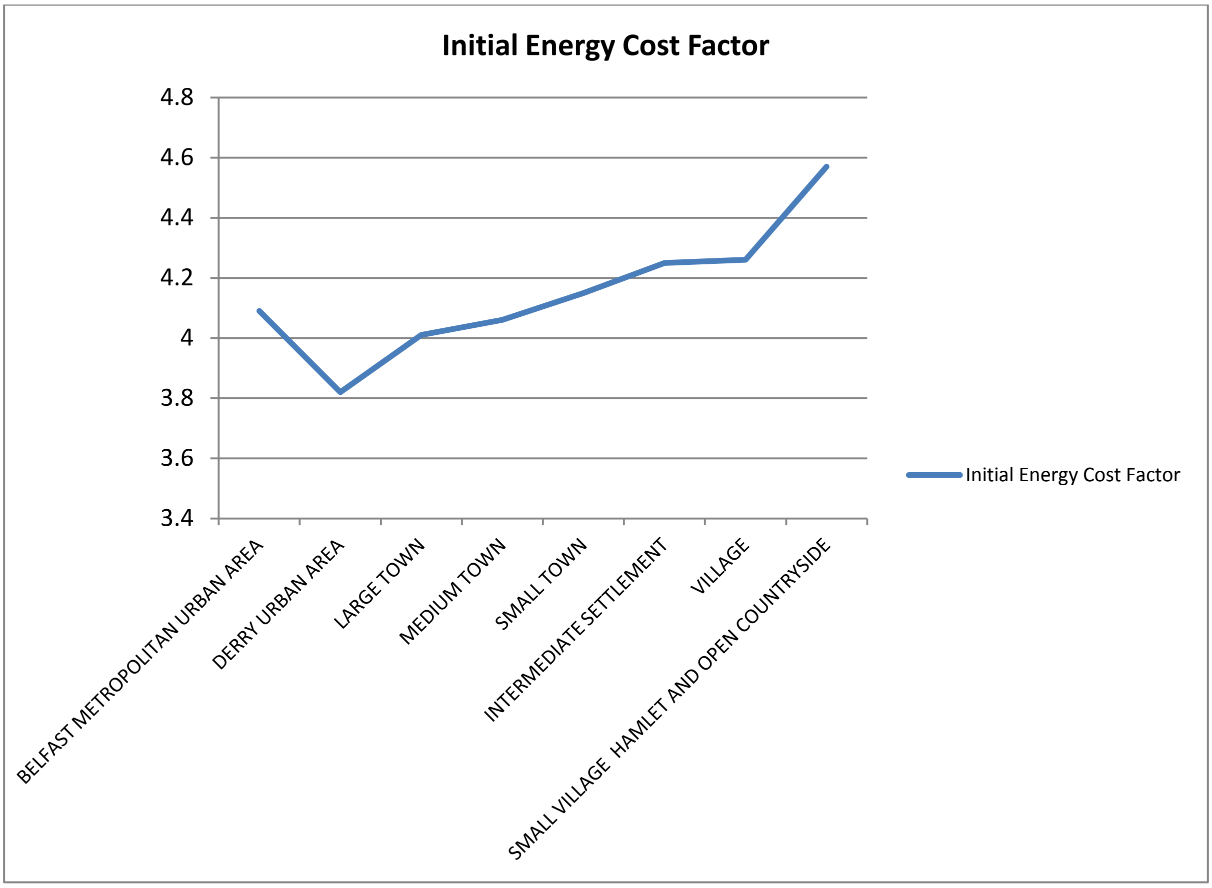
Source: data on small areas from NIHE, Warm Homes and ABA databases
Energy Cost Factor is the BRE-based estimate of actual Energy Costs, prior to application of the scaling used to convert into SAP ratings

Graph 10.1 Average cost of Warm Home Intervention by Location



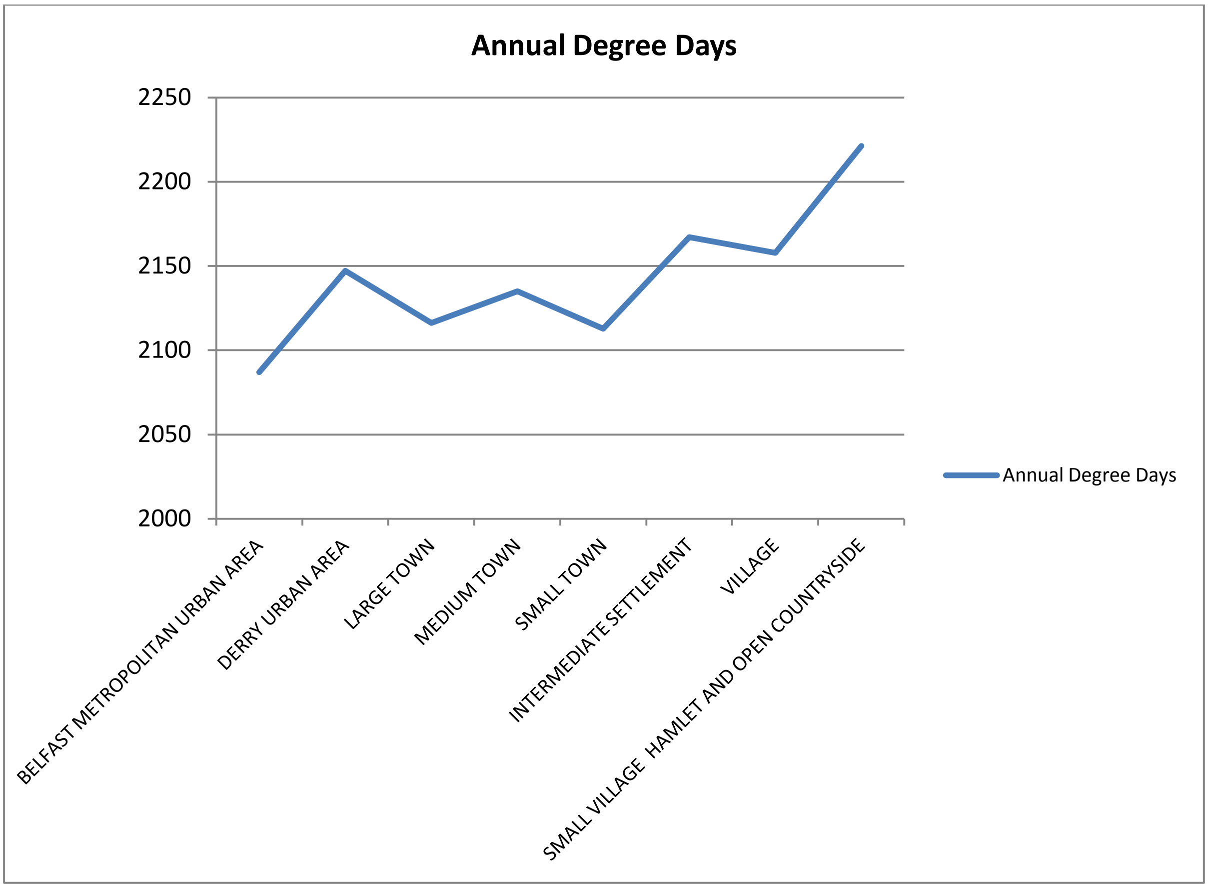
Source: Table 10.4

Graph 10.2 Initial Energy Cost Factor of Warm Homes Interventions by Location



Source Table 10.4

Graph 10.3 Degree-days by Location



Source: Table 10.4

10.13 In summary, therefore:

a. The Northern Ireland average cost of work on the Warm Homes Scheme in recent years is £1490, and an average SAP improvement of 9.8 points has been recorded. There is a considerable variation, however, between Belfast Metropolitan Urban Area (cost of £1216, improvement of 10.6 SAP points – ratio of £115 per SAP point gained) and small villages, hamlets and open countryside (cost £1807, improvement of 8.7 SAP Points – ratio of £208 per SAP point gained).
b. This suggests that improving the housing stock in the most rural of areas is likely to be about 80% more expensive than improving stock in Belfast (or 37% more expensive than the Northern Ireland average).
c. Insulation measures have a similar cost in both owner-occupied and private rented sector, rising by 33% over five years from about £500 in 2006-07 to £670. The cost of heating measures installed has diverged by sector. The cost in 2006-07 was about £3,800 in both sectors. Whilst the value of work on private rented properties remained the same, it increased by 31% over five years for owner-occupied to about £5,000.
d. Applying the local cost of intervention to the estimated local numbers in fuel poverty suggests that the total cost of a retrofit for every house containing a fuel poor household, at recent prices, would be about £454 million for Northern Ireland as a whole. It is an estimate broadly in line with the estimate derived from the CES data This level of expenditure would probably not be sufficient to achieve a target SAP rating of 85 for the units improved.
e. Applying these results to the CES estimate of £1,800 per improvement (2008 prices), it would be reasonable to assume expenditure of £1350 per unit in Belfast and £2450 in small villages, hamlets and open countryside. On a more substantial grant of £6,500, these prices would be £5305 and £7883, with a total cost of £1.72 billion to cover 87% of properties with a household in fuel poverty.
f. If it is assumed that the objective is to improve units to a target SAP rating of 85, and further assumed that the cost per SAP unit gained remains constant., then if all properties in need of improvement have a SAP in the range 40-50, as was the case historically (see Table 10.2), the total cost of improvement is in the neighbourhood of £1.93 billion.
g. Much of the variance of average local cost of works under Warm Homes can be explained by thirteen local variables found to be statistically significant. The model suggests a basic cost of £3,800, which experiences substantial reductions for units in Belfast, Derry and in areas with higher levels of gas uptake, oil price, social housing, owner occupation, room occupancy (households in mid life cycle, smaller houses) and population density (urban vs rural). Spending is greater for units in those areas with higher levels of detached housing, terraced housing, room numbers (bigger houses), older people and annual degree-days (colder areas).
h. Low energy efficiency (ie high energy cost), low density of settlement (Ie greater distance between houses) and high poverty are associated with higher costs of work. Greater availability and use of gas boilers, higher oil prices and colder climate (ie higher number of degree-days) are associated with cheaper work.
i. The lowest cost of work is found in the Belfast Metropolitan Urban Area, where gas is available, settlement is dense and poverty is low, while energy efficiency is good, oil price is high and climate is warm. Highest costs are in small villages, hamlets and open country, where gas is not available and settlement is sparse (though poverty is low). Energy efficiency is poor, oil price is low and climate is cold. There is therefore a strong geographical link to the costs being incurred, with poor housing and absence of gas in cool rural areas.

11 WARM HOMES (BOILER INSTALLATION)

11.1 Table 11.1 shows that according to NIHE supplied data on the period 2002-2009, Warm Homes installed almost 15,000 boilers, principally (about 90%) in the owner-occupied sector. Of these, about 87% were oil boilers (slightly less in the private rented sector.

Table 11.1 Warm Homes boiler installations by boiler type and tenure

Tenure	Boiler Type			
	Don't Know	Gas	Oil	Total
Owner Occupied	.2%	12.9%	86.9%	13,272
Private Renting	.1%	14.9%	85.1%	1,398
Total	.2%	13.1%	86.8%	14,670

Source: NIHE data on Warm Homes boiler installations 2002-09

11.2 Table 11.2 shows that gas boilers were installed by Warm Homes principally in Belfast Metropolitan Urban Area (44% of all installations compared with 5% or less in other urban areas and virtually none in rural areas).

Table 11.2 Warm Homes boiler installations by boiler type and settlement type

Settlement Type	Boiler Type			
	Don't Know	Gas	Oil	Total
BELFAST METROPOLITAN URBAN AREA	.6%	44.1%	55.3%	3,966
DERRY URBAN AREA	0.0%	1.3%	98.7%	707
LARGE TOWN	0.0%	5.2%	94.8%	2,269
MEDIUM TOWN	0.0%	.4%	99.6%	1,229
SMALL TOWN	.1%	3.4%	96.4%	814
INTERMEDIATE SETTLEMENT	0.0%	0.0%	100.0%	506
VILLAGE	0.0%	0.0%	100.0%	637
SMALL VILLAGE HAMLET AND OPEN COUNTRYSIDE	0.0%	.2%	99.8%	4,542
Total	.2%	13.1%	86.8%	14,670

Source: NIHE data on Warm Homes boiler installations 2002-09

11.3 Table 11.3 shows that the mean cost of the Warm Homes installations was about £1,450 (slightly more in rural areas and slightly less in urban). Adjusting for inflation to 2012, this suggests a current cost of about £1,785, compared with current costs quoted by Energy Savings Trust of £2,300, which is 22% higher – a rather considerable mark-up.

Table 11.3 Warm Homes boiler installations by boiler type and location type

Location	Mean Cost (£)	Number	Std. Deviation
Rural	1472.1495	5,685	989.03972
Urban	1440.2791	8,985	917.46351
Total	1452.6297	14,670	945.93824

Source: NIHE data on Warm Homes boiler installations 2002-09

11.4 Table 11.4 shows that there is a significant and substantial correlation between the proportion of gas boiler installations in an area and the cost of boiler work (greater where there are more gas installations), initial energy costs of housing, cost of Warm Home interventions and dispersal of housing (all are less where there are more gas installations ie in Belfast). The cost of boiler installation is higher in the areas where initial fuel costs are higher. Initial energy cost is higher in the areas where the cost of Warm Homes intervention and dispersal of housing is higher. Cost of Warm Homes intervention is higher in areas where dispersal of housing is higher.

Table 11.4 Correlation of costs and area characteristics

	Boiler Gas Proportion (NIHE)	**Local Boiler Cost (NIHE)**	**Initial Energy Cost Factor (Warm Homes)**	**Average Intervention Cost (Warm Homes)**	**Average inter-house distance**
Boiler Gas Proportion	1	.387**	-.101**	-.538**	-.366**
Local Boiler Cost	.387**	1	.142**	-.028**	.051**
Initial ECF	-.101**	.142**	1	.351**	.432**
Average Cost	-.538**	-.028**	.351**	1	.478**
Average inter-house distance	-.366**	.051**	.432**	.478**	1
**. Correlation is significant at the 0.01 level (2-tailed).					

Source: Warm Homes and NIHE data on Warm Homes Boiler installations

11.5 Presumably, gas boilers cost more to install when a gas supply has to be set up as well as the work of actual installation undertaken.

11.6 Table 11.5 shows that in a survey of properties and households in areas identified as likely to have fuel poverty problems, just under a quarter of properties have a boiler aged under ten years old, with 4% having no boiler and 13% having a boiler of unknown age. Almost 30% of properties with a boiler of known age have a boiler aged under ten years and 14% of boilers are of unknown age.

11.7 Annex 7 shows that compared with households with gas boilers, other households are:

- Somewhat more likely to be in newer houses
- Somewhat likely to be in detached or semi-detached than terraced property
- more than twice as likely to pay for electricity using direct debit or cheque rather than pre-payment
- Significantly more likely to be in rural areas than urban

Households with gas or newer (less than five years old) oil boilers are somewhat more likely than other households to be owner occupiers rather than private renters.

11.8 The proportion of properties where the age of the boiler is unknown is greatest among those properties where the age of the property is also unknown (44%) and least among houses built after 2005 (0%). The highest levels of unknown boiler age are found amongst properties built 1945-1976 (12.5% of boilers) and 1977-1984 (11.2%), compared with only 8.2% for properties built before 1919 and 5.2% for properties built 1991-1999.

Table 11.5 Age of boilers by age of property

When was the property built?	How old is your boiler?									
	0-5 years	6-9 years	10-15 years	16-20 years	21 years plus	Don't know	Not applicable	Total	Boilers of under 10 years old as % of boilers of known age	Boilers of unknown age as % of all boilers	Boilers of over 15 years old as % of boilers of known age
Pre 1919	18.00%	9.90%	20.20%	15.90%	21.90%	7.70%	6.40%	233	32.5%	8.2%	44.0%
1920-1944	14.00%	16.00%	22.70%	17.30%	14.70%	9.30%	6.00%	150	35.4%	9.9%	37.8%
1945-1976	14.90%	9.60%	26.30%	21.80%	12.30%	12.10%	3.00%	1135	28.9%	12.5%	40.2%
1977-1984	6.80%	15.30%	31.50%	20.70%	11.30%	10.80%	3.60%	222	25.8%	11.2%	37.4%
1985-1990	10.80%	9.20%	32.30%	23.10%	13.80%	9.20%	1.50%	65	22.4%	9.3%	41.4%
1991-1999	7.70%	10.30%	32.10%	35.90%	6.40%	5.10%	2.60%	78	19.5%	5.2%	45.8%
2000-2005	11.60%	30.20%	48.80%	2.30%	0.00%	7.00%	0.00%	43	45.0%	7.0%	2.5%
2006-2012	30.80%	46.20%	15.40%	0.00%	0.00%	0.00%	7.70%	13	83.3%	0.0%	0.0%
Don't know	6.20%	7.50%	16.20%	11.90%	10.60%	41.20%	6.20%	160	26.1%	44.0%	42.9%
Total	13.30%	11.20%	26.00%	20.00%	12.80%	13.00%	3.80%	2099	29.4%	13.5%	39.4%

Source: ABA survey of properties in areas identified as having issues of fuel poverty

11.9 For boilers with a known age, the lowest proportions aged under ten years (20-30%) are found in properties built in the period 1945-1999. Higher proportions are found in pre-war properties (33-35%) and properties built after 1999 (ie themselves aged no more than 12 years old). The proportion of boilers known to be eligible for replacement grant (ie aged over 15 years) is about 37-45% in all ages of property save those built after 1999, where the proportion drops to near zero[20].

11.10 These results suggest that it is reasonable to assume that older properties have often (if by no means always) undergone a retrofit with modern kit being installed when this happens, while post-war properties have experienced a drift into obsolescence with the kit installed at construction. Total absence of something like central heating is probably a more powerful incentive to action than dwindling efficiency of an existing system.

11.11 Extrapolating from these results, it may be argued that 40% of pre-2000 properties have boilers aged over 15 years. As there were about 630,000 occupied properties in 2001-02, there could be as many as 250,000 boilers eligible for replacement grant. This compares with the approximately 15,000 boilers installed by Warm Homes over a seven year period. Even if a radical discount is made of the number of boilers eligible for replacement (to 150,000), replacing them would take about 70 years to achieve at the rate achieved 2002-09, at a total cost of £267.8 million at 2012 prices (£3.8 million per annum). This takes no account of those additional boilers reaching an age of 15 years and becoming eligible for replacement.

[20] Theoretically, a 12 year old property could have a 16 year old boiler eg if a builder installed a second-hand boiler. It is more likely that a result of this kind is an error of reporting or recording.

11.12 In summary, therefore:

a. In the period 2002-2009, Warm Homes installed almost 15,000 boilers, principally in the owner-occupied sector. Of these, about 87% were oil boilers.
b. Gas boilers were installed principally in Belfast Metropolitan Urban Area (44% of all installations compared with 5% or less in other urban areas and virtually none in rural areas).
c. The mean cost of the installations was about £1,450 (slightly more in rural areas and slightly less in urban). This suggests a current cost of about £1,785, compared with current costs quoted by Energy Saving Trust which are 22% higher.
d. There is a significant and substantial correlation between the proportion of gas boiler installations in an area and the cost of boiler work (greater where there are more gas installations), initial energy costs of housing, cost of Warm Home interventions and dispersal of housing (all are less where there are more gas installations ie in Belfast). The cost of boiler installation is higher in the areas where initial fuel costs are higher. Initial energy cost is higher in the areas where the cost of Warm Homes intervention and dispersal of housing is higher. Cost of Warm Homes intervention is higher in areas where dispersal of housing is higher.
e. Among properties and households in areas with fuel poverty problems, just under a quarter of properties have a boiler aged under ten years old.
f. The proportion of properties with boilers of unknown age amongst properties built 1945-1976 is 12.5% and 11.2% for properties built 1977-1984 compared with only 8.2% for properties built before 1919 and 5.2% for properties built 1991-1999.
g. The lowest proportions of boilers aged under ten years (20-30%) are found in properties built in the period 1945-1999. Higher proportions are found in pre-war properties (33-35%) and properties built after 1999 (ie themselves aged no more than 12 years old). The proportion of boilers known to be eligible for replacement grant (ie aged over 15 years) is about 37-45% in all ages of property save those built after 1999, where the proportion drops to near zero.
h. It is likely that older properties have undergone a retrofit with modern kit being installed when this happens, while post-war properties have experienced a drift into obsolescence with the kit installed at construction. Total absence of something like central heating is probably a more powerful incentive to action than dwindling efficiency of an existing system.
i. Possibly as many as 40% of pre-2000 properties have boilers aged over 15 years. As there were about 630,000 occupied properties in 2001-02, there could be as many as 250,000 boilers eligible for replacement grant. This compares with the approximately 15,000 boilers installed by Warm Homes over a seven year period. Even if a radical discount is made of the number of boilers eligible for replacement (to 150,000), replacing them at the rate achieved 2002-2009 would take about 70 years to achieve, at a total cost of £267.8 million at 2012 prices (£3.8 million per annum).

12 RETROFIT AND SAP

12.1 Energy Saving Trust & Affinity Sutton (2011) examine the costs of various interventions for a range of 22 archetypes. Twelve are terrace houses, with the rest being flats and maisonettes. Table 12.1 shows their findings, with a range from £4 for a low energy light bulb to £9,100 for photovoltaic panels.

Table 12.1 Costs of interventions

Costs	Fixed	Marginal	
Cavity Wall insulation		15.1	Psm
Loft insulation (Top-up)	64	6.7	Psm
Internal Wall Insulation	2356	72.8	Psm
Floor Insulation	2814	59.2-77.3	Psm
Insulated doors		1175-1223	Ea
Foam Insulated DHW cylinder		1038	Ea
Insulation jacket		39.5	Ea
Double glazing		585	Ea
Reduced infiltration A – to 5m³/m².h		964	Ea
Reduced infiltration B - to1m³/m².h (incl. Heat Recovery)		3402	Ea
Heat Recovery		4336	Ea
Low energy light bulbs		4.2	Ea
Heating controls		41-782	Ea
Condensing boiler replacement (gas)		2055	Ea
Low flow water fittings		59-74	Ea
Photovoltaic panels		9112	Ea

Source: Energy Saving Trust and Affinity Sutton

12.2 Comments recorded suggest a certain tendency to regard the residents as an obstacle to progress eg “site managers suggest that overall there were delays to work programme on a third of the properties, with around 18% attributed to supply chain issues and 10% due to resident issues (such as access to the property, agreeing measures to be installed, etc).” Elsewhere, it is recorded with regard to loft insulation that, ”In instances where the loft top-up fully covered the floor joists, residents were concerned about not being able to use their lofts for storage.” It might be suggested that accommodating the needs of the residents should be viewed as a primary concern, rather than a source of delay.

12.3 None of the archetypes used are particularly representative of rural housing stock.

12.4 Table 12.2 shows that various forms of wall insulation cost between £500 and £11,200 on average, with a payback period of between 5 and 23 years. A payback period of 15 years is taken as an acceptable norm. The savings required to secure a payback period of 15 years are shown for a range of other retrofits, and these savings need to be quite substantial. Conversion of an old boiler would need savings about equivalent to those secured through cavity wall insulation, as would installation of a wood stove or a roof wind turbine. Solar water heaters, solar photovoltaic generators, pellet stoves and air source heat pumps need to produce savings akin to those of solid wall insulation. Pellet boilers, ground source heat pumps and pole wind turbines need to secure much larger savings.

Table 12.2 Costs, savings and payback period of various retrofit interventions

Intervention	Average Cost	Range	Saving (pa)	Payback period
Cavity wall insulation	£475	£450-500	up to £140	4.8
Solid wall insulation (Interior)	£7,000	£5,500-8,500	£460	15.2
Solid wall insulation (Exterior)	£11,200	£9,400-13,000	£490	22.9
Convert old gas boiler to A rated condensing boiler	£2,300		*£153*	
Convert old non-gas boiler to A rated condensing gas boiler	£2,300	Plus cost of gas connection	*Over £153*	
Pellet stove	£4,300		*£287*	
Log stove	£2,150		*£143*	
Pellet boiler	£11,500		*£767*	
Air source heat pump	£8,000	£6,000-10,000	*£533*	
Ground source heat pump	£13,000	£9,000-17,000	*£867*	
Solar photovoltaic	£7,500	£5,500-£9,500	*£500*	
Solar water heater	£4,800		*£320*	
Wind turbine (roof)	£2,000		*£133*	
Wind turbine (pole)	£17,500	£15,000-20,000	*£1,167*	

Source: Energy Saving Trust (Northern Ireland)
Savings shown in italics are the level of annual saving required to secure a 15 year payback period

12.5 Richards Partington Architects (2012) report on the lessons learned through careful monitoring of the retrofitting of a 1930s semi-detached house in York considered representative of many urban and town houses in Britain (nothing is said concerning rural housing). The project investigated a standard retrofit (cavity wall insulation, seal chimney, loft insulation, airtightness, rewire and replaster, insulation around garage, new heating and hot-water system), followed by a radical retrofit (further work on airtightness, EWI, MVHR, solar hot water, under-floor insulation and high-performance doors and windows). It is noted that the radical retrofit had high capital costs and the level of disruption involved would have probably have meant any occupants moving out for the duration of the works (the cost of this rehousing is not added to the cost of the project).

12.6 Together, the retrofits achieved a 79% saving per annum, with carbon emission reduced by 66%. SAP was increased from 59 to 89. The standard retrofit reached SAP 77 and cost £18,250 with the radical retrofit costing a further £37,750. Table 12.3 shows the full details, and it is clear that the benefits from the radical refit are three times as expensive as those from the standard retrofit, with the payback period increased from 48 years (ie exceeding the life expectancy of the majority of occupants) to 145 years (ie exceeding the life expectancy of a building already about eighty years old ie notional capital value has already depreciated close to zero by standard accounting conventions). It was noted that for both levels of retrofit, the actual level of improvement proved to be well below theoretical indications (73-71% of expectation for standard and radical respectively).

Table 12.3 Impact of retrofits

	Cost	SAP	Energy Cost (2009)	CO_2 emission (kg pa)	£ per SAP point gained	Energy saving (£ pa) per £000 spent	Repayment period	CO_2 reduction (kg pa per £000 spent)
Base	0	59	803	5,751	na	na	na	na
Standard Retrofit	18,250	77	423	3,121	1,014	20.8	48.0	144.1
Deep Retrofit	37,750 extra	89	163	1,269	3,146	6.9	145.2	49.1
Ratio of Standard to Deep Retrofit					3.10	3.02	3.02	2.94

Source: Richards Partington

12.7 Table 12.4 shows that on the Northern Ireland costings suggested by Energy Saving Trust, the annual savings required to secure a 15 year payback of the initial investment may be used to categorize a range of interventions into six groups. Taking cavity wall insulation (the sole intervention in Group 1) as the comparator, boiler conversion, together with roof wind turbine and log stoves (Group 2) require savings 4-5 times greater. Pellet stoves and solar water heaters (Group 3) require savings ten times as great as those achieved by cavity wall insulation, while for solid wall insulation (interior), solar photovoltaic systems and air source heat pumps, the savings must be 16-17 times as great. For solid wall insulation (exterior), pellet boilers and ground source heat pump, this rises to a factor of 25 and for pole wind turbines, to a factor of 40.

Table 12.4 Various interventions grouped by required annual saving for 15 year payback

Intervention	**Required annual saving for 15 year payback**	**Group**
Cavity wall insulation	£32	1
Wind turbine (roof)	£133	2
Log stove	£143	2
Convert old gas boiler to A rated condensing boiler	£153	2
Convert old non-gas boiler to A rated condensing gas boiler	Over £153	2
Pellet stove	£287	3
Solar water heater	£320	3
Solid wall insulation (Interior)	£466	4
Solar photovoltaic	£500	4
Air source heat pump	£533	4
Solid wall insulation (Exterior)	£748	5
Pellet boiler	£767	5
Ground source heat pump	£867	5
Wind turbine (pole)	£1,167	6

Source: Energy Saving Trust (collated and adapted)

12.8 Stafford, Gorse and Shao (2011) note (p11) that 61% of housing stock in NI has been built since 1959. They address six themes, finding that retrofit isn't simple since performance is not always as in the laboratory. Building energy performance is not well understood and there is a need to establish how buildings actually work. Their findings suggest that the whole of a building is not simply the sum of the parts. There is a need to understand behaviour of building fabric, although they suggest that organisations often prefer to go for non-fabric solutions. It is desirable, they note, to handle micro-generation and low carbon technology as part of an integrated solution. Since it is people who use energy, it is important to understand occupant behaviour, although they suggest that "take-back" may be a cover for failure of the technology to deliver. They also note the importance of ICT and monitoring, with reference to the need for communication of results.

12.9 Shipworth (2011) suggests that there is no evidence from relevant surveys of change between 1984 and 2007 in the temperatures to which houses are heated. The discrepancy between recorded consumption of energy at the macro-level and aggregated estimates of consumption at the micro-level may have come about from a number of causes, including the failure of energy efficiency measures to deliver the anticipated improvements.

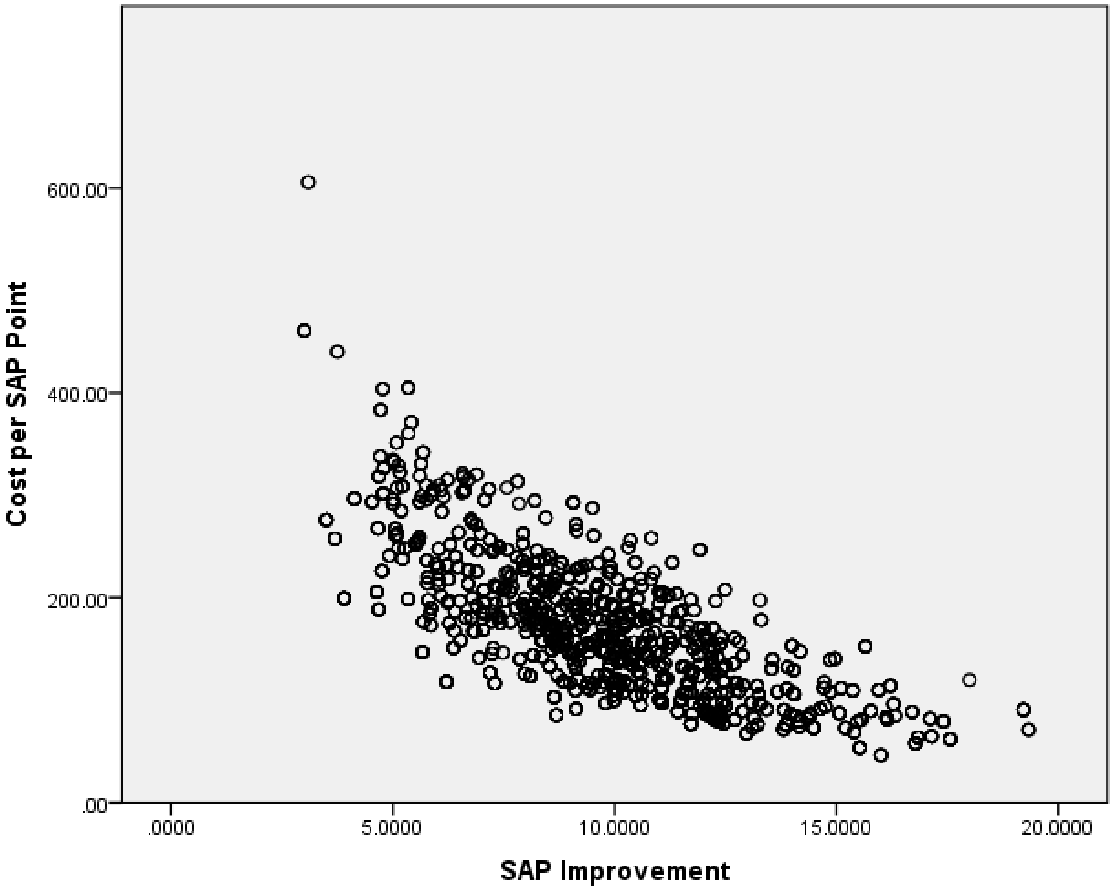
12.10 Table 12.5, based on Northern Ireland Warm Homes data, suggests that the cost per SAP point of improvement increases as the initial SAP increases (+0.209 correlation), but the achieved SAP improvement decreases (-0.502 correlation). The strongest of the three relationships is the increased SAP improvement associated with decreased cost per SAP point (-0.738 correlation). The underlying data is portrayed graphically in Graph 12.1. All of the correlations are statistically significant.

Table 12.5 Correlation of Northern Ireland SAP Ratings with level and cost of improvement

Correlations				
		Initial SAP	**Cost per SAP Point**	**SAP Improvement**
Initial SAP	Pearson Correlation	1	.209**	-.502**
	Sig. (2-tailed)		.000	.000
	N	4537	4537	4537
Cost per SAP Point	Pearson Correlation	.209**	1	-.738**
	Sig. (2-tailed)	.000		.000
	N	4537	4537	4537
SAP Improvement	Pearson Correlation	-.502**	-.738**	1
	Sig. (2-tailed)	.000	.000	
	N	4537	4537	4537
**. Correlation is significant at the 0.01 level (2-tailed).				

Source: Warm Homes data

Graph 12.1 Cost per point of SAP improvement against overall SAP improvement achieved



Source: Warm Homes data

12.11 Applying the figures quoted by Energy Saving Trust and Affinity Sutton to a notional cuboid 7 x 7 x 7 metres[21] suggests costs of the order of £400 for loft insulation, £3,000 for cavity wall insulation and £16,600 for internal wall insulation. Prices of this order could easily generate costs of the level reported by Rowntree, when supplemented by other measures.

12.12 The simplest explanation of the discrepancy between these sorts of costs, and those derived from Warm Homes data, is that the latter relate to cheap measures applied to properties with poor SAP ratings, while the former are derived by examination of "cutting edge technology" applied to houses that are already quite energy efficient.

12.13 In summary, therefore:

a. The cost of retrofit interventions can vary widely, from £4 to £9,100 for kit. It is however possible to become over-concerned with the work programme rather than the beneficiaries. A radical retrofit can be considerably more expensive than a standard retrofit, even when the cost of rehousing the occupants for the duration of the work is excluded.
b. Savings can be as much as 80% of energy costs, but with long or very long payback periods. Achieved improvement can be 25-30% less than anticipated. Building energy performance is not well understood and there is a need to establish how buildings actually work. Their findings suggest that the whole of a building is not simply the sum of the parts. Since it is people who use energy, it is important to understand occupant behaviour, although they suggest that "take-back" may be a cover for failure of the technology to deliver as there is no evidence of change in the temperatures to which houses are heated. The discrepancy between recorded consumption of energy at the macro-level and aggregated estimates of consumption at the micro-level may have come about from a number of causes, including the failure of energy efficiency measures to deliver the anticipated improvements.
c. NI data suggests that the cost per SAP point of improvement increases as the initial SAP increases but the achieved SAP improvement decrease. There is increased SAP improvement associated with decreased cost per SAP point.
d. Costs could be of the order of £400 for loft insulation, £3,000 for cavity wall insulation and £16,600 for internal wall insulation (for a notional cuboid 7m x 7m x 7m). Warm Homes data could relate to cheap measures applied to small properties with poor SAP ratings.

[21] This provides comparison costs on a consistent, and not wholly unrealistic, basis. It avoids the problem of variations in the mix of house type and size which impact on overall averages derived from particular programmes

13 SAP IMPROVEMENTS AND ENERGY SAVINGS

13.1 Table 13.1 shows that in 2006, 42% of households in houses with SAP rating of under 64 (below proposed minimum recommended) are in fuel poverty, compared with 17% for those in houses with SAP rating 64, but under 78 (acceptable, but below recommended) and 10% of those in houses with SAP rating 78 or higher (recommended or better). By 2009, this has risen to 52%, 30%, and 13% respectively. Expressed in terms of likelihood of fuel poverty, this is an increase of 49.6%, 109.2% and 34.5%, indicating that the worst effect is experienced by those in properties considered acceptable, but below recommended SAP. It should be noted that even in 2009, nearly half of the households in the lowest banding are not in fuel poverty. This means that targeting houses for improvement by SAP rating alone will have a considerable potential for redundancy.

Table 13.1 Fuel Poverty by SAP Rating, 2006 & 2009

	SAP 2006 Rating			
Fuel Poverty 2006	Under 63	63, under 78	78 & over	**Total**
No	58.0%	83.0%	90.3%	433,148
Yes	42.0%	17.0%	9.7%	225,582
All	457,852	191,809	9,069	658,730
Fuel Poverty 2009				
No	47.7%	69.8%	86.9%	389,145
Yes	52.3%	30.2%	13.1%	302,314
All	436,188	238,114	17,157	691,459

Source: NI House Conditions Survey 2006 & 2009

13.2 Given the level of local variation in climate, it seems reasonable to adjust the NI minimum and recommended SAP levels to take account of local climate (district degree days). Table 13.2 shows that when this is done, the limits within district councils are noticeably different from the Northern Ireland limits. This is reflected in the proportion of cold properties ie those falling below minimum, with Omagh and Magherafelt having substantially more (18-19% more) cold properties, and Craigavon and Belfast having notably less (9-10% less).

Recommendation

set Northern Ireland specific SAP targets (possibly: minimum acceptable SAP 64, recommended SAP 78, ideal SAP 85)

13.3 Table 13.3 shows that when local SAP rating is used, 41% of households below recommended minimum acceptable SAP are in fuel poverty (cf 42% using the NI minimum), with 18% for households at minimum acceptable, but below recommended target (cf 17%) and 16% for households at recommended target SAP or above (cf 10%). This suggests that when local standards are applied, the households in the best houses are not in fact as much better off than those in the intermediate houses as might appear the case from using a NI standard. Those in the worst houses remain substantially worse off.

Table 13.2 Properties below NI and local SAP minimum by District Council

District	Total Properties	Local SAP standard		% Under NI Minimum Acceptable SAP	% Under local Minimum Acceptable SAP	Ratio Local: NI
		Recommended Minimum Acceptable	Recommended Target			
Omagh	19,149	68	83	68.9	81.7	1.19
Magherafelt	14,264	66	80	72.7	85.7	1.18
Newtownabbey	34,512	66	80	61.1	69.6	1.14
Banbridge	18,140	66	81	65.6	74.3	1.13
Ballymoney	12,113	66	80	67.9	76.1	1.12
Lisburn	42,648	66	81	72.5	81.1	1.12
Fermanagh	22,903	65	80	75.4	83.9	1.11
Larne	13,131	66	80	74.6	80.7	1.08
Moyle	7,880	66	80	69.9	75.5	1.08
Ballymena	22,964	66	81	74.5	79.1	1.06
Down	28,299	65	79	64.7	68.2	1.05
Cookstown	12,442	66	81	78.0	81.5	1.04
Strabane	15,017	66	81	82.1	85.6	1.04
Derry	41,323	64	78	65.6	67.7	1.03
Limavady	12,162	65	80	72.0	73.1	1.02
Coleraine	26,233	64	78	71.2	71.2	1.00
Antrim	18,563	64	79	69.6	69.6	1.00
Armagh	20,818	64	78	74.2	74.2	1.00
Newry and Mourne	34,350	64	78	74.0	74.0	1.00
Dungannon	20,790	63	77	63.2	62.2	0.98
North Down	32,450	63	76	82.4	80.7	0.98
Ards	30,881	62	76	78.7	76.7	0.97
Castlereagh	28,544	63	77	64.7	62.5	0.97
Carrickfergus	16,621	63	77	60.9	56.4	0.93
Craigavon	34,168	63	76	75.0	68.6	0.91
Belfast	124,580	62	75	64.9	58.5	0.90
Northern Ireland	704,945	64	78	70.0	71.1	1.02

Source: NI House Conditions Survey 2006

Table 13.3 Fuel Poverty 2006 by local SAP banding

Fuel Poverty 2006	Local SAP Band			Total
	Below Recommended Minimum Acceptable	At Recommended Minimum, but not at Recommended Target	At Recommended Target or above	
No	58.9%	82.3%	84.5%	433,148
Yes	41.1%	17.7%	15.5%	225,582
All	465,840	181,171	11,719	658,730

Source: NI House Conditions Survey 2006

13.4 Assuming that it is possible to target for improvement only those properties below the local SAP minimum occupied by a fuel poor household, and that the properties targeted are no different from the generality of such local properties. Table 13.4 shows the level of improvement and expenditure required to bring the targeted properties up to the minimum local standard. This would amount to £663 million in total, which is rather higher than the estimate derived from the CES model, despite the more limited scope of this estimate (treating about 210,000 properties in total) and its rather earlier price base. The initial assumptions are, of course, not robust, being somewhat optimistic about the possibility of precise targeting, and the amount of work needed.

Table 13.4 Estimate of 2006 cost to improve Low SAP property occupied by those in Fuel Poverty

District	Total Properties	Local SAP Minimum	% under Local Minimum SAP	Mean SAP Rating under Minimum SAP	Properties to improve	Mean SAP Improvement required	Total SAP Point Improvement	Average Cost per SAP Point	Total Price (£)	% Fuel Poverty	Price to Target Fuel Poor (£)
Antrim	18,563	64	69.6	49.0	12,920	15.0	193,922	200.3	38,833,175	30.2%	11,724,681
Ards	30,881	62	76.7	44.5	23,686	17.5	413,987	107.3	44,401,415	44.8%	19,910,390
Armagh	20,818	64	74.2	41.4	15,447	22.6	348,466	167.5	58,364,848	43.0%	25,105,065
Ballymena	22,964	66	79.1	40.1	18,165	25.9	470,772	141.3	66,517,123	42.4%	28,221,049
Ballymoney	12,113	66	76.1	48.6	9,218	17.4	160,107	196.3	31,435,126	38.3%	12,053,628
Banbridge	18,140	66	74.3	42.4	13,478	23.6	318,076	153.7	48,883,569	40.9%	19,986,181
Belfast	124,580	62	58.5	46.2	72,879	15.8	1,151,873	113.0	130,188,675	44.2%	57,487,441
Carrickfergus	16,621	63	56.4	45.6	9,374	17.4	162,769	164.2	26,719,857	46.1%	12,316,791
Castlereagh	28,544	63	62.5	51.7	17,840	11.3	201,129	98.1	19,721,921	33.0%	6,515,678
Coleraine	26,233	64	71.2	45.9	18,678	18.1	337,902	202.1	68,273,842	40.3%	27,526,052
Cookstown	12,442	66	81.5	43.7	10,140	22.3	226,193	227.0	51,353,169	46.7%	23,966,327
Craigavon	34,168	63	68.6	45.6	23,439	17.4	407,397	159.0	64,764,694	41.2%	26,697,521
Derry	41,323	64	67.7	41.6	27,976	22.4	627,018	187.6	117,640,780	38.5%	45,337,779
Down	28,299	65	68.2	46.8	19,300	18.2	351,909	168.5	59,281,281	47.6%	28,216,146
Dungannon	20,790	63	62.2	42.3	12,931	20.7	268,185	208.4	55,896,196	42.6%	23,794,586
Fermanagh	22,903	65	83.9	43.0	19,216	22.0	423,305	210.9	89,255,212	48.6%	43,349,405
Larne	13,131	66	80.7	44.2	10,597	21.8	231,522	147.0	34,043,043	48.4%	16,482,673
Limavady	12,162	65	73.1	40.2	8,890	24.8	220,647	195.5	43,137,290	33.2%	14,313,043
Lisburn	42,648	66	81.1	49.0	34,588	17.0	589,357	126.9	74,803,065	40.5%	30,286,651
Magherafelt	14,264	66	85.7	47.4	12,224	18.6	227,401	235.4	53,530,591	40.3%	21,589,189
Moyle	7,880	66	75.5	45.8	5,949	20.2	120,294	233.0	28,029,925	58.7%	16,459,155
Newry and Mourne	34,350	64	74	41.4	25,419	22.6	574,347	185.2	106,366,706	46.0%	48,918,475
Newtownabbey	34,512	66	69.6	49.2	24,020	16.8	404,110	169.7	68,586,351	32.0%	21,927,202
North Down	32,450	63	80.7	45.0	26,187	18.0	471,240	95.1	44,793,346	39.5%	17,707,589
Omagh	19,149	68	81.7	45.9	15,645	22.1	345,530	214.3	74,041,210	41.5%	30,735,104
Strabane	15,017	66	85.6	44.9	12,855	21.1	270,733	271.5	73,503,016	45.3%	33,286,144
Northern Ireland									1,572,365,426		663,913,946

Table 13.5 Impact of improving SAP for fuel poor in properties in need of improvement

District	Total Properties	Low SAP Properties	Low SAP Properties, Fuel Poor	Average Property Energy Cost Factor (ECF)			Local Minimum ECF	Total ECF x Property	Reduction	% Reduction
				Total	Low SAP	Low SAP, Fuel Poor				
Antrim	18,563	12,920	3,902	3.35	3.83	4.72	2.58	62,173	8,344	13.4
Ards	30,881	23,686	10,611	3.76	4.22	4.77	2.72	116,173	21,712	18.7
Armagh	20,818	15,447	6,642	4.00	4.63	5.43	2.58	83,336	18,918	22.7
Ballymena	22,964	18,165	7,702	4.23	4.82	5.70	2.44	97,209	25,119	25.8
Ballymoney	12,113	9,218	3,530	3.48	3.89	4.23	2.44	42,102	6,313	15.0
Banbridge	18,140	13,478	5,513	3.96	4.60	6.16	2.44	71,845	20,512	28.6
Belfast	124,580	72,879	32,213	3.25	4.02	4.18	2.72	404,724	47,083	11.6
Carrickfergus	16,621	9,374	4,321	3.30	4.17	4.32	2.65	54,797	7,219	13.2
Castlereagh	28,544	17,840	5,887	3.05	3.53	3.97	2.65	87,148	7,795	8.9
Coleraine	26,233	18,678	7,527	3.57	4.14	4.34	2.58	93,748	13,266	14.2
Cookstown	12,442	10,140	4,735	3.95	4.35	4.63	2.44	49,104	10,391	21.2
Craigavon	34,168	23,439	9,657	3.50	4.06	4.39	2.65	119,439	16,783	14.1
Derry	41,323	27,976	10,771	3.46	4.05	4.64	2.51	142,886	22,962	16.1
Down	28,299	19,300	9,187	3.64	4.51	4.78	2.65	103,100	19,582	19.0
Dungannon	20,790	12,931	5,509	4.14	4.52	4.98	2.51	86,126	13,596	15.8
Fermanagh	22,903	19,216	9,339	3.90	4.32	5.12	2.44	89,209	25,027	28.1
Larne	13,131	10,597	5,129	4.13	4.86	5.92	2.51	54,275	17,506	32.3
Limavady	12,162	8,890	2,951	3.50	3.84	4.36	2.44	42,627	5,668	13.3
Lisburn	42,648	34,588	14,008	3.83	4.64	6.06	2.58	163,450	48,738	29.8
Magherafelt	14,264	12,224	4,926	3.70	3.96	4.37	2.44	52,780	9,504	18.0
Moyle	7,880	5,949	3,492	3.65	4.14	4.29	2.44	28,782	6,462	22.5
Newry and Mourne	34,350	25,419	11,693	4.06	4.72	5.55	2.58	139,609	34,732	24.9
Newtownabbey	34,512	24,020	7,686	3.26	3.80	4.24	2.44	112,656	13,801	12.3
North Down	32,450	26,187	10,344	3.78	4.16	4.80	2.65	122,761	22,205	18.1
Omagh	19,149	15,645	6,493	3.80	4.22	4.71	2.29	72,776	15,710	21.6
Strabane	15,017	12,855	5,823	3.97	4.28	4.83	2.44	59,618	13,907	23.3
Northern Ireland	704,945	501,061	209,592	3.35	3.83	4.78	2.57	2,552,453	472,854	18.5

Low SAP Properties are those below local Minimum SAP
Properties targeted are Low SAP properties where occupants are in fuel poverty. It is assumed that such properties have their Energy Cost Factor (ECF) reduced from the district average ECF for Low SAP properties with Fuel Poor occupants to the ECF for the local Minimum SAP

13.5 SAP scores are not usable as a measure of real world impact because of the different mathematical manipulations applied to derive scores in different parts of the SAP range[22]. It is necessary to reverse engineer the SAP score to the underlying Energy Cost Factor (calibrated to the range 0-10).

Recommendation

take account of the impact of the computational changes made for presentational reasons in the conversion of Energy Cost Factors into SAP ratings.

13.6 When this is done, Table 13.5 shows the impact of the proposed programme in terms of reducing energy costs (and to a large extent, of reducing energy consumption). The reduction in costs would vary from 9% in Castlereagh to 32% in Larne, with an overall reduction of 19% for the whole of Northern Ireland. This seems plausible since the programme would be targeting about 30% of the NI occupied housing stock with the aim of reducing their estimated energy costs (UK prices) by over 50%. The targeted properties probably account for about 40% of NI's estimated energy costs.

13.7 In summary, therefore:

a. In 2006, about 42% of households in houses with SAP rating of under 64 (below proposed minimum acceptable) are in fuel poverty, compared with 10-17% for those in houses with higher SAP In 2009, nearly half of the households in the lowest banding were not in fuel poverty. This means that targeting houses for improvement by SAP rating alone will have a considerable level of redundancy.
b. Given the level of local variation in climate, it seems reasonable to adjust the NI minimum and recommended SAP levels to take account of local climate (district degree days). Omagh and Magherafelt have substantially more (18-19% more) cold properties, and Craigavon and Belfast have notably less (9-10% less).
c. When local SAP rating is used, 41% of households below minimum SAP are in fuel poverty, with 16-18% for households in warmer houses.
d. Based on improvement of targeted properties to local SAP standards expenditure of about £663 million would be needed.
e. The impact of the proposed programme in terms of reducing energy costs (and to a large extent, of reducing energy consumption) is a reduction in costs that would vary from 9% in Castlereagh to 32% in Larne, with an overall reduction of 19% for the whole of Northern Ireland.

[22] Approximately half of the SAP 2006 scale (1-52) is related logarithmically to energy cost, and the rest is linked in a linear manner eg the Energy Cost Factor of a SAP 20 property is 4.7 times that of a SAP 80 property, not 4.0 times as might be deduced from the SAP values.

14 POTENTIAL BENEFITS OF RETROFIT

14.1 The intended impact of the work proposed (Para 13.6) in terms of reducing energy costs (and to a large extent, of reducing energy consumption) is a reduction in costs that would vary from 9% in Castlereagh to 32% in Larne, with an overall reduction of 19% for the whole of Northern Ireland. In addition to this, other benefits may be expected.

Job Creation

14.2 The Northern Ireland Audit Office (2012, p84) finds that the cost per net job (CPJ) created within Invest NI's client companies between2005-06 and 2007-08 was £23,300 (£17,500 for indigenous firms and £25,900 for Foreign Direct Investment (FDI)). The former seems the more appropriate comparator group. Hart, Driffield, Roper and Mole (2007, p10) find that the cost-per-job estimate for Northern Ireland was £25,549 for single-plant locally owned businesses in the period 1998-2004. Adjusting these costs to 2013 prices[23], the cost is estimated as £23,000 or £44,000 respectively. The average probably provides as good a measure as any.

14.3 The cost of creating a public sector sponsored job is thus perhaps about £33,500. In addition to the labour costs, there is a benefit to the manufacturing and retailing sectors that produce and distribute the kit used, although a substantial fraction of this benefit will not accrue to Northern Ireland.

14.4 Cambridge Econometric Service (2012) presents an assessment of the economic and environmental impacts of investing in energy efficiency in fuel poor households (of which it estimates there will be 9.1 million households at risk by 2016), comparing this with a number of alternative government investment strategies. In these, the principal focus is on scenarios which postulate that the government spends all or most of the product of energy-related taxes on energy efficiency measures[24]. The report suggests that there are 6.8m fuel poor homes that can be treated for less than £10,000, and treating them would eradicate fuel poverty in 75% of the households projected to fall under fuel poverty by 2016. Table 14.1 shows the key characteristics and summary results for two of the main scenarios, compared to the other government investment scenarios.

[23] The CPI was used. Technically, this index is inappropriate since it measures the inflation experienced by households, not businesses, but it is easily accessible and approximates the adjustment required.

[24] The likelihood of this postulated situation occurring is probably about the same as the likelihood of government devoting the product of Vehicle Tax to road improvement, or funding pensions from National Insurance. HM Treasury has a deep-rooted and long-standing aversion to hypothecated taxes.

Table 14.1 Summary of short-term modelling results from Cambridge Econometric Service

For 2015	EE-All	GK-All	EE-T	GK-T
Annual carbon price revenue (£m 2008 prices)	2786.60	2786.60	2786.60	2786.60
Annual fiscal stimulus (£m 2008 prices)	2618.00	2618.00	963.00	963.00
Total Homes Treated ('000s)	1094.90	n/a	821.20	n/a
Annual jobs created ('000s FTE)	71.00	64.50	26.60	23.60
GDP impact %	0.20	0.21	0.08	0.08
Annual energy bill savings per household treated (£ 2008 prices)	237.40	n/a	231.30	n/a

EE-All: Energy Efficiency (All)
GK-All: General Government Investment (All)
EE-T: Energy Efficiency (Targeted)
GK-T: General Government Investment (Targeted)
Source: Table ES.1 Cambridge Econometric Services (2012)

14.5 The study suggests that Investing in energy efficiency measures in fuel poor households has a similar or more positive macro-economic impact than an equivalent stimulus package either through increases in government current spending (e.g. NHS, education) or government capital spending (e.g. roads, building hospitals), or reductions in VAT or fuel duty. Each of the three spending options causes an increase in economic output, but investment in energy efficiency has the added and persisting benefit of also reducing natural gas imports. If households spend less on energy imports, they are able to spend more on other products and services, which are in part supplied domestically. Energy security is also improved.

14.6 The positive impact of the energy efficiency investment on GDP is also reflected in jobs. In 2015, the EE-T (Energy Efficiency-Targeted) and EE-All (Energy Efficiency-All) scenarios create 26,600 and 71,000 jobs, respectively. The difference is because spending in the latter is almost three times greater. These jobs are created firstly in the construction industry and its supply chain but the jobs diffuse throughout the economy.

14.7 The modelled increase in employment is broadly consistent to findings from other countries. In 2009 the German KfW eco-refurbishment programme stimulated nearly €8bn of private and public sector investment in energy efficiency building, leading to 128,000 additional jobs. This compares to Cambridge Econometric Service's finding that around £2.6bn of investment in 2015 would stimulate 71,000 jobs. This is a similar number of jobs per unit of investment (about 1 job per £36,600 of investment and in line with initial expectations on cost per job).

14.8 MacFlynn (2013, p7) suggests that £10 million of investment would generate 330 jobs ie about £30,300 per job. This is the cheapest cost per job of the three estimates, but all three are broadly similar.

14.9 In terms of investment per house treated, the CES estimate amounts to between £1,173 and £2,391 each, and in terms of houses treated per job created, between 15.4 and 30.8 houses treated annually per job. It is not clear exactly what kit and work are being purchased through this investment[25], but although the work rate does not seem high[26], it should be born in mind that not all of the work generated will be on site.

14.10 The estimate assumes domestic energy consumption in 2010 for the UK of 551,842 GWh, implying that Northern Ireland domestic consumption amounts to 4.2% of the UK. Given that the 2011 NI population amounts to 2.9% of the UK population, this suggests that NI per capita energy consumption is 45% higher than the national average. Whether this is an artefact of the statistics or a genuine discrepancy, caution is indicated in extrapolating from the UK results to findings for Northern Ireland.

14.11 On a simple pro-rata to population basis, Northern Ireland might expect to secure between 23,800 and 31,750 treatments (say 27,800) per annum, and between 770 and 2,050 jobs (say 1,400), at a cost of about £1,800 (2008 prices). Given that for 2011, the estimated number of households in fuel poverty is about 296,800, this rate of treatment would take over ten years to cover all households, and cost £534,200,000 (say £50,000,000 per annum at 2008 prices).

14.12 This is, of course, a hypothetical calculation, since not all households need an improvement to their housing stock in order to escape fuel poverty. It is just as well that it is hypothetical since it seems unlikely this level of funding could be secured by Northern Ireland[27]. Other sources suggest a higher level of grant eg Washan (2012) suggests a grant of £6,500 over fifteen years would remove 87% of fuel poverty. Other estimates are even higher. Jenkins (2010) suggests costs (average of estimates) for social housing of about £19,500 per house.

14.13 In summary, therefore:

a. The cost of creating a public sector sponsored job is perhaps about £33,500.
b. Cambridge Econometric Service (2012) suggests a cost per job of £36,600 of investment.
c. Out of the UK scenario, Northern Ireland might expect to secure between 23,800 and 31,750 treatments (say 27,800) per annum, and between 770 and 2,050 jobs (say 1,400), at a cost of about £1,800 (2008 prices).
d. Given that for 2011, the estimated number of households in fuel poverty is about 296,800, this rate of treatment would take over ten years to cover all households, and cost £534,200,000 (say £50,000,000 per annum at 2008 prices).

Mortality and Health

14.14 The proportion of deaths occurring on days with a temperature of less than 11.1^{o}C is less than the proportion of person-days exposed to such temperatures. Table 14.2 shows differentials of 5.3 (respiratory causes), 2.4 (circulatory cause) and 0.3 (other causes) percentage points. It implies that about 6.7% of deaths in the period 2001-06 occur because higher death rates are found on days when temperatures are below 11.1^{o}C. Since Excess Winter Deaths (2001-06) are 508 pa on average (3.51% of all deaths) this

[25] From an econometric viewpoint, this is largely immaterial,

[26] A three person work crew would treat about two houses weekly if the larger amount were being invested, or one house per week if the lesser amount were being invested. What they would be doing the rest of the time is unspecified.

[27] It is in excess of 12.5% of the current DSD housing budget.

suggests that there are 462 temperature-related deaths occurring in the non-winter period ie in Northern Ireland, the temperature effect is about 2.2 as great in winter as in summer, with the result that only about 52% of temperature-related deaths occur in the period December-March.

Table 14.2 Percentage of deaths 2001-06 occurring on days of a given temperature, compared with the percentage of person-days exposed to these temperatures

Cause of Death	Percentage on day with temperature				Total Deaths	Percent below 11.07 degrees
	15.59 degrees or over	11.07 degrees, under 15.59	6.55 degrees, under 11.07	Under 6.55 degrees		
Other	18.1%	30.8%	32.1%	18.9%	31472	51.1%
Circulatory	16.9%	29.9%	33.3%	19.9%	24948	53.2%
Respiratory	15.4%	28.5%	34.2%	21.8%	9039	56.1%
All causes	17.3%	30.2%	32.9%	19.7%	65459	
All Days	17.6%	31.6%	31.9%	18.9%		50.8%

Source: Mortality data drawn from the Northern Ireland Longitudinal Study

14.15 Annex 8 presents the results of a regression of Excess Winter Death rates in the period 1991-2010 against location, fuel poverty and rurality, for English local government areas. It explains only 18% of the variance found, but all the terms are statistically significant. If Northern Ireland were regarded as an English local authority and the regression applied, this would currently suggest average excess winter deaths of the order of 2,300 per year. The actual observed Excess Winter Deaths in Northern Ireland (800 per annum 1990-2009) is commensurate with a Fuel Poverty rate of only about 14% (about half the lowest fuel poverty rate recorded for Northern Ireland in the last thirteen years).

14.16 This demonstrates that caution is required in extrapolating results derived from English experience to the Northern Ireland situation. It is likely that in English local government areas, Excess Winter Deaths form a much higher proportion of temperature-related deaths than is the case in Northern Ireland[28]. Since fuel poverty may be expected to impact on all temperature-related deaths, not simply those occurring in winter, the English equation works better in England than when taken out of context.

14.17 In Newham (London), it was found for older residents (65 and over) in 1993, excess winter morbidity is 70% higher in areas of high fuel poverty risk (69% in 1996). Provision of central heating in Scotland is associated with better physical functioning and general health, with significantly less chance of heart disease or high blood pressure (69-77%). Insulation interventions for houses with asthmatic children resident were associated in New Zealand with halving of poor health, fewer days off and reduced use of medical services. Similar effects, though less marked, were recorded from installation of non-polluting heating sources looked at reductions in asthma following insulation and found indications that better cost benefit results were obtained from applying basic interventions (1.87:1) than from targeted intervention to improve existing insulation (1.09:1) and untargeted intervention (0.31:1).

[28] The climate in England is mostly colder in winter and usually warmer in summer than the climate in Northern Ireland.

14.18 Studies on the health impacts of fuel poverty are abundant, but are usefully summarised in Fenwick et al., 2013; Liddell & Morris. 2010 and Thomson et al., 2013. A landmark publication in 2013 came from Hilary Thomson's team in Glasgow viz. the Cochrane Review of *Housing Improvement as an Investment to Improve Health*. This was Thomson's second such Review, the first having been published in 2009. The revised conclusions have been made with the benefit of a larger body of evidence, much of it improved in terms of methods and sample sizes. The team conclude:

> "*Improvements in warmth and affordable warmth may be an important reason for improved health. Improved health may also lead to reduced absences from school or work. Improvements in energy efficiency and provision of affordable warmth may allow householders to heat more rooms in the house and increase the amount of usable space in the home. Greater usable living space may lead to more use of the home, allow increased levels of privacy, and help with relationships within the home. An overview of the best available research evidence suggests that housing which promotes good health needs to be an appropriate size to meet household needs, and be affordable to maintain a comfortable indoor temperature*."

14.19 Cost-benefit analyses concerned with tackling fuel poverty have been more abundant in 2013 than ever before. Thomson's team published a summary of costs and benefits (Fenwick et al., 2013), which contains useful summary tables, but concludes that the field of economic evaluation is still primitive. More sophisticated economic assessments are needed in future studies, preferably guided by a health economist, since many opportunities to establish real evidence for costs and benefits have been missed in the past.

14.20 Another cost-benefit analysis was published by Viv Mason of BRE. She is an advocate of the HHSRS methodology for calculating NHS savings from retrofits, and this publication takes estimation a step further, illustrating how health risk "hotspots" can be identified in local authorities, through GIS mapping of local data. This can target intervention to where it is most needed, thereby maximising the returns on investments made. The report also estimates that, of all the NHS savings that can be made from retrofitting homes, 78% of these savings derive from preventing illnesses and deaths related to excess cold; of the remainder (which include preventing falls, electrical hazards, food hazards, sanitation risks, and intruders) the next most cost-effective retrofit in terms of NHS savings is tackling damp and mould. Hence more than 80% of all potential NHS savings that can be made from tackling indoor housing risks, derive from conditions associated with fuel poverty.

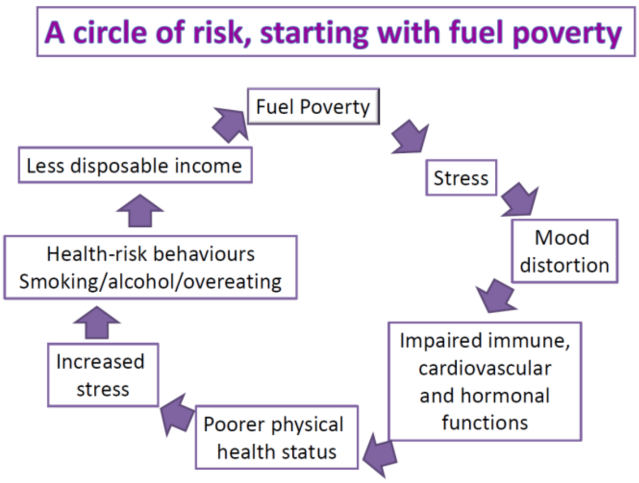
14.21 Researchers at Imperial College London published findings concerning respiratory health and fuel poverty among older people (Webb et a., 2013). Older people in fuel poverty had significantly poorer peak expiratory flow rates after accounting for covariates which, the authors argue, is in keeping with the hypothesised physiological routes by which cold and damp affect lung function.

14.22 A qualitative report from researchers at the University of Edinburgh (De Haro, et al., 2013), concerned people in Edinburgh in high rise flats, which could not be connected to the gas grid for safety reasons (common in high-rise flats). The researchers sought the views of tenants, and results reflect the same consistent themes of health impacts as have been reported in many other qualitative studies of the past:

- depression and an inability to get warm during winter (common in all respondents, but especially among black and ethnic minorities)
- aggravation of chest problems (especially among children and those with a pre-existing respiratory illness)
- aggravation of arthritis and other pain-related conditions
- need to stay in heated public buildings as much as possible when the weather is cold
- going to bed early and getting up late to curtail the day.

14.23 Finally, one of the year's landmark meetings of experts in fuel poverty was convened by the International Energy Agency in Copenhagen in Spring 2013. Academics and public health experts were commissioned to spend 2 days deliberating on the content of a forthcoming Handbook on energy efficiency, fuel poverty, and their impacts on human wellbeing. The Handbook is to be published in early 2014. During the 2 day session, some of the greatest progress was made in understanding more about how fuel poverty affects mental health and wellbeing. A causal pathway model was explored, based on current WHO deliberations about mental health, risk and resilience. It appeared to fit most of the data presented on this sub-topic, and is illustrated on Figure 14.1.

Figure 14.1: Potential circle of risk engendered by fuel poverty



Source: Liddell, 2013

14.24 The causal pathway model remains speculative, but it is possible that, by breaking the link between fuel poverty and stress, other concomitant risks, especially to physical health, could be reduced, yielding satisfactory strategic returns on investment. Data from a recent Glasgow study, which were presented by Ade Kearns at the same meeting, seemed to support this, as did data from the Warm Front evaluation team of Jan Gilbertson and Geoff Green.

14.25 An article published in the Journal of the Royal Statistical Society (Beatty et al., 2013) explores the heat or eat phenomenon in the UK. Households in the bottom quartile of expenditure distribution reduce spending on food during cold weather shocks, and the reduction is almost mirror imaged by the increase in spending on fuel. What studies have yet to determine is the extent to which people *actually eat less i*n cold weather in order to afford heat. It has been possible to demonstrate in several studies that they buy less food in cold weather, but since cold is often accompanied by snow, ice, frost, and high winds, this may be as much a reflection of people not going shopping. People do not travel outdoors as much in cold weather which, as we know from other studies, accounts for the fact that there are fewer falls and outdoor accidents in cold weather than in warmer weather, despite more hazardous conditions.

14.26 Nevertheless, the authors introduce a useful new concept to the literature, namely that of "*reducing health capital*": whilst they do not believe the reduction in food spending will, of itself, cause grievous harm at the time, they speculate that these spells of cold weather shock may, over time "run down the stock of health capital and have medium to long term health effects".

14.27 In summary, therefore:

a. There are 508 Excess Winter Deaths per annum in Northern Ireland and a further 462 temperature related deaths outside the winter period.
b. Caution is required in extrapolating results derived from English experience to the Northern Ireland situation. It is likely that in English local government areas, Excess Winter Deaths form a much higher proportion of temperature-related deaths than is the case in Northern Ireland.
c. It has been found for older people (65 and over), excess winter morbidity is 70% higher in areas of high fuel poverty risk. Provision of central heating is associated with better physical functioning and general health, with significantly less chance of heart disease or high blood pressure. Insulation interventions for houses with asthmatic children resident were associated with halving of poor health, fewer days off and reduced use of medical services. Similar effects, though less marked, were recorded from installation of non-polluting heating sources looked at reductions in asthma following insulation and found indications that better cost benefit results were obtained from applying basic interventions than from targeted intervention to improve existing insulation and from untargeted intervention.
d. The links between public health and human wellbeing are becoming areas of intense research and speculation
e. Cost-benefit analyses are beginning to predominate, accompanied by a call for these to be completed using more rigorous methodologies
f. Impacts on mental health and wellbeing are gaining prominence, with these currently being construed as part of the causal pathway that links fuel poverty with human health. Hence, physical health impacts are now being conceptualised as both direct and indirect effects, with the latter mediated through improved wellbeing.

Carbon Emissions

14.28 A rough calculation in respect of Northern Ireland suggests that if the number of gas customers increased by 12.7% (average annual growth rate over the period 2005-2010), the switch of about 18,400 customers from non-gas, non-electricity to gas would reduce carbon generation by 1.75%.

15 RESPONSE OF RECIPIENTS

15.1 Fuel poverty is estimated on the basis of the cost of the energy required by the current housing kit to heat accommodation of a household to a healthy temperature (as defined by the World Health Organisation). This is not the same as the cost of the energy actually used by the household, which may be more or less than the fuel poverty estimated cost, depending on requirements and preferences of the household. It is thus entirely possible to take a household out of fuel poverty, without affecting its actual consumption at all. In fact, a household may even be enabled to increase consumption of energy, whilst holding the cost constant or affecting only a small saving (the rebound effect).

15.2 It is important to remember that the response of recipients is dependent on their interpretation of their experience, not on the original intentions of those making the intervention. Haas and Biermayr (2000) report on an analysis which shows a 20-30% rebound effect for a group of Austrian households that had undergone energy efficiency improvement and increased their energy consumption. Love (nd) refers to a situation where energy use increases at some efficiency changes and decreases with others.

15.3 Boardman (2012) comments that "The discrepancies result from the difference between econometric modelling and a perspective that starts with people, their priorities and behaviour. The latter is the approach taken here. An analysis that takes people's priorities as the starting point involves a very different perspective. In particular, a focus on energy services, for instance warmth, rather than the acquisition of energy".

15.4 Sunikka-Blank, Chen, Britnell & Dantsiou (2012), reporting on the implementation of an energy-efficient retrofit in social housing and the related energy use behaviour in a case study in the UK, observed that despite their original motivation, the tenants found the retrofit process difficult and disruptive. This seems something that likely to reduce motivation[29].

15.5 Furthermore, the researchers report that quality of building construction plays only a limited role in determining an actual energy performance in domestic buildings. Households can use three or more times as much energy for heating as their neighbour, even if they live in identical homes and sufficient deviation in comfort temperatures should be allowed after a retrofit, more than what the standards of conventional comfort theory may indicate. It is very hard to estimate standard energy consumption for even identical buildings in simulations, or policies related to retrofit. Lifestyle changes have been found to be more effective. Policy instruments such as FIT and SmartMeters are based on the rational choice models that assume that people make rational decisions, but in practice, there seems to be irrational economic behaviour.

15.6 Increasing consumption is not necessarily irrational, as the installation of energy efficiency measures alters the calculus of value for money. Increasing energy consumption by 10% after installation of measures increasing energy efficiency from 40% to 50% increases the heat received by 38%, whereas the same increase in consumption when energy efficiency has been increased from 80% to 90%, yields an increase in energy received of 24% - still a substantial increase, but quite discernibly less. Those in poor

[29] As does the attitude demonstrated by the slogan "Our ideas, your home" (Hotpoint). This seems to suggest that the suppliers know what is needed, and so the householders should allow suppliers a free hand in arranging their homes.

quality houses have the greatest incentive to increase consumption and the greatest capacity to do so.

Table 15.1 Factors affecting ability of vulnerable older folk to keep warm

Theme	Sub-Theme	Examples
Awareness	Knowledge	Safe/recommended temperatures
	Information	Health impacts of cold weather
	Past experience	Using technology (heating, information and finance)
		Fuel payment and tariffs
Behavioural Influences	Age	Different generations > or <75
	Mindset and values	Thrift
		Protective of privacy
		Protective of independence
		Hardiness and stoicism
		Pride
		Trust
		Fearful
		Prefer routine to change
	Social connections	Living with or near family/friends
		Trusting of family/friends
		Family/friends informed and supportive
		Dependent/independent
		Isolated
Barriers	Money	Income
		Fuel costs
		Household expenditure
	Technology	Heating kit
		Communication
		Banking, eg, direct debits, online banking
	Money and finance	Prefer cash
		Dislike credit
		Prefer post office
		Closing down of high street banks
		Electronic and online banking
	Visibility	Past experience fuel and payment visible (coal and cash)
		Now fuel and payment invisible (gas/electric and direct debit/
		online banking)
		Older people invisible in society
	Disjointed systems	Fragmentation
		Duplication
		Referral disjointed

Source: Tod , Lusambili, Home, Abbott , Cooke, Stocks , & McDaid (2012)

15.7 Tod , Lusambili, Home, Abbott , Cooke, Stocks , & McDaid (2012) document a range of issues that affect the ability of vulnerable older people to keep warm (see Table 15.1). These include knowledge of the issues and past experience of operating systems both physical and administrative; attitudes and social networks of support, and a range of barriers to success which include technology, banking, visibility and disjointed systems. Although this study was carried out among older people, it is likely that many of the issues raised would be raised by younger people too. The study related to the general task of heating a household, but it seems probable that although retrofits would raise a further range of specific issues, the concerns raised regarding heating in general will colour attitudes to retrofits.

Recommendation

seek to be sensitive to the needs and wishes of the owners and occupants of housing identified as suitable for retrofit

15.8 It is likely that one effect of retrofits likely to be of interest to owners (not tenants) is the impact on house prices. Table 15.2 shows that in England, an average increase of £16,000 in house price is associated, all else being equal, with an EPC rating of B rather than D (the increase is rather more between bands G and E). There is regional variation.

Table 15.2 Energy Rating and Dwelling Prices in England: Potential £ value increase

£ value increase from properties moving from :		
	EPC D to B	EPC G to E
England average	£16,009	£16,701
North East	£19,265	£25,355
North West	£12,979	£23,155
Yorkshire & Humberside	£15,945	£17,298
East Midlands	£10,936	£10,177
West Midlands	£16,882	£9,282
East of England	*	*
South East	*	*
South West	£16,342	£8,026
London	£1,100	£41,808

* Result is not statistically significant at the regional level
Source: DECC (2013)

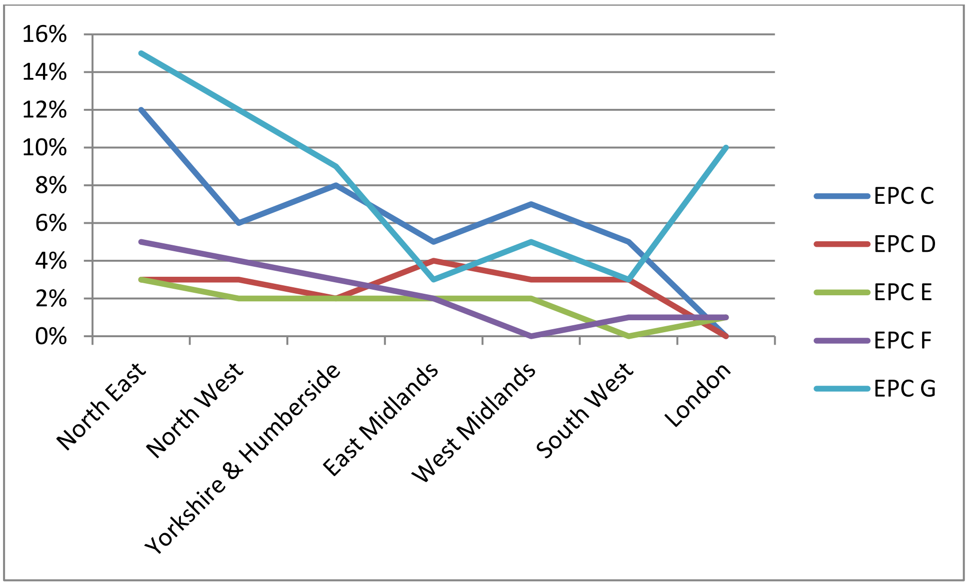
15.9 Table 15.3 and Graph 15.1 show that in percentage terms, the largest differentials between G rated and A/B rated are found in the northern parts of England (24-38%). When analysed in detail, many regions shows a more substantial improvement in price from G rating to F rating than for other improvements. For London, this is the only substantial improvement.

Table 15.3 Energy Rating and Dwelling Prices in England: Potential % value increase

Value increase based on properties moving from EPC G to:					
	EPC A/B	EPC C	EPC D	EPC E	EPC F
England average	14%	10%	8%	7%	6%
North East	38%	26%	23%	20%	15%
North West	27%	21%	18%	16%	12%
Yorkshire & Humberside	24%	16%	14%	12%	9%
East Midlands	16%	11%	7%	5%	3%
West Midlands	17%	10%	7%	5%	5%
East of England	7%	5%	*	*	4%
London	12%	12%	12%	11%	10%
South East	*	*	*	*	*
South West	12%	7%	4%	4%	3%

* Result is not statistically significant at the regional level
Source: DECC (2013)

Graph 15.1 Percentage increase in Dwelling Prices (based on prices of G rated Dwellings) in some England regions from Energy Rating band to Energy Rating band above



Source: Table 15.2

15.10 Fuerst, McAllister, Nanda and Wyatt (2013) suggest that the regional differential may be attributed to the colder conditions of the north of England. Alternatively, a constant price premium accounts for a smaller fraction of the higher priced properties of the south and east [the absolute variation in prices tends to be greater in the north, which suggests that this explanation is less likely]. Thirdly, it may be that the greater housing demand in the south and east means that purchasers place less value on energy efficiency and more on property location and size [the substantial increase from G rating to F rating suggests that even so, minimum standards are demanded].

15.11 Fuerst el al also demonstrated the absence of an energy efficiency premium for detached properties until these are divided into those in sparsely inhabited areas [countryside] and those in densely inhabited areas [settlement]. Detached houses in the countryside form

5% of the working sample of the study. The premium for energy efficiency is much the same for detached properties in settlement areas as for semi-detached properties. Detached properties in the countryside are more heterogeneous.

15.12 In the Northern Ireland context, given its climate and housing market, it is likely that a price premium of about 30% applies between the worst and the best properties in energy performance terms. The robustness of this estimate is weakened by the impact of detached countryside properties which amount to 18% of NI households (cf 5% of English sales).

15.13 In summary, therefore:

a. It is important to remember that the response of recipients is dependent on their interpretation of their experience, not on the original intentions of those making the intervention. Energy use can increase as a response to some efficiency changes and decrease with others.

b. Despite their original motivation, the tenants can find the retrofit process difficult and disruptive. This seems something that likely to reduce motivation.

c. Quality of building construction plays only a limited role in determining an actual energy performance in domestic buildings. Households can use three or more times as much energy for heating as their neighbour, even if they live in identical homes and sufficient deviation in comfort temperatures should be allowed after a retrofit, more than what the standards of conventional comfort theory may indicate.

d. It is very hard to estimate standard energy consumption for even identical buildings in simulations for policies related to retrofit. Lifestyle changes have been found to be more effective. Policy instruments such as FIT and Smart Meters are based on the rational choice models that assume that people make rational decisions, but in practice, there seems to be irrational economic behaviour.

e. Increasing consumption is not however necessarily irrational, as the installation of energy efficiency measures alters the calculus of value for money. Those in poor quality houses have the greatest incentive to increase consumption and the greatest capacity to do so.

f. There are many issues which impact on the willingness of householders to engage in warmth management, including retrofits. These are by no means all economic.

g. In the Northern Ireland context, given its climate and housing market, it is likely that a price premium of about 30% applies between the worst and the best properties in energy performance terms. The robustness of this estimate is weakened by the impact of detached countryside properties which amount to 18% of NI households (cf 5% of English sales).

16 TARGETING FUEL POVERTY

16.1 Estimates of Fuel Poverty produced by the Building Research Establishment (BRE) for the UK House Conditions Surveys are based on a very complex model which is by no means transparent to the user. The model takes account of differences in regional climatic conditions, but there is no evidence that any adjustment is made for sub-regional variations (eg heat islands, altitude, exposure) which can be quite as great. Where sub-regional data exists, it is appropriate to take some account of this.

16.2 Table 16.1 shows the average target rating of small areas, analysed by district council, where target rating is computed from the number estimated to be in fuel poverty, adjusted by the ratio of local annual degree-days to Northern Ireland annual degree-days. Omagh and Strabane have the highest rating (95 and 93, respectively) compared with Carrickfergus and North Down (45 and 43, respectively) and a Northern Ireland rating of 61. Between North Down and Ballymoney (84), there is a fairly regular increase in rating for district councils, but Omagh and Strabane stand alone, markedly worse off than Ballymoney.

Table 16.1 Target Rating of small areas by local government district

Local Government District	Mean Rating
Omagh	94.7
Strabane	93.2
Ballymoney	84.0
Limavady	80.8
Dungannon	77.7
Cookstown	75.9
Ballymena	74.1
Armagh	71.4
Magherafelt	70.9
Banbridge	68.7
Fermanagh	68.7
Moyle	68.0
Coleraine	66.5
Lisburn	63.6
Derry	63.3
Larne	62.5
Newtownabbey	61.2
Antrim	60.0
Craigavon	57.9
Down	57.1
Castlereagh	55.5
Newry and Mourne	52.4
Ards	50.3
Belfast	49.4
Carrickfergus	45.3
North Down	42.9
Total	61.0

Source: Estimated numbers in fuel poverty and estimated degree-days

C . THE WAY FORWARD

17 SYNTHESIS OF EMERGING ISSUES

Decision Making

17.1 Plans should be linked to the local context in which they are expected to operate. It should not be assumed that evidence that an intervention has worked somewhere amounts to evidence that it will work locally.

Policies

17.2 There are a great many government policies relevant to a retrofit project. Unfortunately these operate in a less than co-ordinated way.

Climate

17.3 There is considerable regional variation in the climate of the British Isles. Northern Ireland is warmer in winter, colder in summer, than many other parts of the UK. It cannot be assumed that measures and heating regimes appropriate to the South East of England are equally appropriate to Northern Ireland or other northern and western regions.

There is also a considerable sub-regional variation in Northern Ireland, reflecting urban heat islands, altitude and proximity to the sea, and the proportion of the population exposed to relatively colder weather varies from under 10% around Belfast to over 40% in the west and centre of Northern Ireland.

Housing

17.4 Tenure, whether owner occupation, social rented or private rented, has an effect on the willingness of households and/or owners to participate in improvements. Turnover of households in properties is ten times higher for private tenants, compared with owner-occupiers. This makes it likely that private landlords will prefer to improve a property when it is vacant (when rent adjustment is easier).Different approaches to implementation of improvements will be required, dependent on tenure.

Almost 10% of Northern Ireland properties are vacant at any given moment. Deep retrofits are most easily carried out in vacant properties, and poses problems when eligibility for assistance is determined by the circumstances of the resident household.

Since 2001, there has been a small decline in owner-occupation, and a marked shift from social rented to private rented. Private sector housing starts form the majority of housing starts (still 74-79% even after recession, which reduced the proportion).

Owner-occupation is most common in the open country, as are detached properties, which are intrinsically least energy efficient. Build of rural single dwellings, whether new or replacement, is currently a major part of all house building. With 26% of NI households lying in the country, the issue of rurality is not one that can be readily disregarded

Energy, Carbon Dioxide emissions and Renewable energy

17.5 The quality of statistical information on electricity and gas supply in Northern Ireland is not good eg the reported number of electricity customers exceeds the number of properties, and has recently increased in excess of recorded house construction.

The existing town gas system of Northern Ireland was closed in the early eighties rather than converted to natural gas. Since 1996, a new gas network has been slowly built up, but despite plans to extend the broad coverage of the gas network to all parts of Northern Ireland, this will not reach the whole population, with the rural population remaining largely excluded. At best, 70% access seems the maximum level achievable.

Gas consumption has increased in the period 2005-2010, partly due to colder winters. Between 2001 and 2011, the proportion of properties without central heating dropped to 1%. While gas central heating has increased, this appears to have been at the expense of non-oil central heating rather than oil.

The dominant source of domestic heating energy in Northern Ireland is oil, with gas and electricity accounting for only 11% of energy consumed. This compares with approaching 25% of all domestic energy. Grid electricity generates about two-thirds more carbon dioxide per unit of energy than a direct burn. Renewables are currently a fairly minor component of domestic heating.

The use of renewable energy is not quite the same as saving of carbon emissions. Natural gas is a low carbon emitter, by comparison with oil, coal or peat. Consequently, a switch from oil or solid fuel to gas, assuming that consumption of renewables remains constant, produces an increase in the percentage of carbon emission that due to renewable sources, rather than an increase in percentage of energy due to renewable sources. There is a range of kit available, though in the case of solar power, property orientation has a considerable impact of the available energy..

17.6 In Great Britain, home carbon dioxide emission by the most wealthy households, by income, is double that of the poorest (rising to treble when the effects of travel are added in). The more rural an area, the greater the carbon dioxide emission with households in villages etc producing a quarter more carbon dioxide than urban households for home use (a fifth more overall). Government energy policies deliver greatest benefits to urban and rural households, with actual disadvantage to households in the open country.

It is likely that higher income households are responsible for more carbon dioxide emission in Northern Ireland, just as in Great Britain, This is reinforced by the more rural nature of Northern Ireland, with lower incomes in the rural west, where natural gas is for the most part unavailable and oil is the fuel used, with higher levels of carbon dioxide emission.

The likelihood is that carbon policy and taxation work to the disadvantage of Northern Ireland. The interaction of the government policies works to the disadvantage of dispersed rural populations (not villages) and Northern Ireland has such a dispersed rural population. The Northern Ireland commitment to rural-proofing policies, if carried out robustly, might well mitigate against the adoption of such policies, to the extent that Northern Ireland has any say in the matter.

Designs with a view to maximising passive solar gain can secure 15-30% heating from this source. Many single new properties in the country have in fact replaced an older property that has been subsequently abandoned, which may be regarded as extreme retrofitting. Oil is viewed as the traditional energy source. The effectiveness of this is very much influenced by orientation.

SAP Rating

17.7 SAP (Standard Assessment Procedure) is calculated using: floor area; height; area of doors, windows and walls; storeys; structure, thickness and conductivity of materials of construction; thermal bridges; roof pitch; building alignment; chimneys, flues, vents and flueless gas fires; ventilation systems; heating system; hotwater use and water heating system; overshading and local terrain. Modifying any of these will change the SAP. Most components of the measure can be adjusted, at a cost that depends on the extent of the work done, which may be quite limited or very considerable.

SAP notes the possibility of lower cost improvement measures such as cylinder thermostats, heating controls, low energy lights, draught-proofing, and insulation of loft or cavity wall. Higher cost measures include boiler and heater upgrades, particularly using biomass. There are also further measures of varying cost, such as solar water heating, double and secondary glazing, solid wall insulation, condensing oil or gas boilers, photovoltaic measures and wind turbines.

SAP calculations assume a single standard UK-relevant latitude, climate and fuel cost, in order to compare properties on an equal footing. It is arguable that in practice, this is not particularly relevant to the needs of the household living in the property. There is some variation in SAP rating by English region, but it is by no means clear whether the differences identified are sufficient to negate the variations in climate between the various regions.

17.8 There is a considerable decline in the comfort/cheapness afforded by a SAP70 house as one passes from Lands End to John O'Groats. On a climatic basis, Northern Ireland might be reasonably placed in Banding 4 (North West to Highlands & Western Isles). The intra-regional variation within Northern Ireland would be equivalent to about half the inter-regional variation of Great Britain.

Appropriate recommended and minimum SAP ratings for Northern Ireland would be 78 and 64 respectively, suggesting a need for energy efficiency perhaps 15-25% greater than in the South West of England in order to maintain the same standard of comfort and cost. The ideal SAP rating might be 85. This is conservative.

17.9 In the period 2001-2011, social housing In Northern Ireland remained substantially better than private sector property, whether rented or owner-occupied, despite the transfer of properties from the social to the private sector. Detached houses and bungalows had noticeably lower SAP ratings than terraced and semi-detached houses.

Fuel Poverty

17.10 In 2011, some 42.2% of households (296,800) suffered from fuel poverty. The level was higher in private rented accommodation, older and retired households, non-working households, bungalows, isolated rural settlement, pre-war properties and low income households. Northern Ireland households are much more likely than Great Britain households to turn down their heating on grounds of cost, and find their homes too cold.

Households using natural gas were less likely to report cold, and households using other fuels without a new boiler were most likely to report cold. Households using fuels other than natural gas without a new boiler are least common in the Belfast Metropolitan Urban Area (especially Belfast, Carrickfergus and North Down).

Rural Areas, Poor Housing and Poverty

17.11 The proportion of dispersed housing in Northern Ireland is about 37%, but this proportion rises from 7% in the Belfast Metropolitan area to 58% in villages. In small villages, hamlets and open countryside, the proportion is 97%.

About 75% of non-sparse areas of Belfast Metropolitan Urban Area have access to natural gas, compared with less than 2% of areas in the open countryside. It is estimated that the proportion of households in fuel poverty in sparse areas is 47%, compared with 39% in non-sparse areas. Within settlements the proportion in fuel poverty is about 35-45%, regardless of dispersal. For the open countryside, it is 51% and for small villages and hamlets, 56%. This suggests that the most rural areas are most subject to fuel poverty.

Although poor housing and poverty tend to be associated, the link is rather stronger in rural areas. Rural areas tend to have more poor housing and higher energy costs. Areas with low levels of problematic housing are rarely rural, whether poverty is low (2% is rural) or high (1% is rural), with low being defined as less than median for both poverty and problematic housing. Areas with high problematic housing and low poverty are 17% rural, and areas with high problematic housing and high poverty are 39% rural.

Areas with high levels of problematic housing have predominately detached properties. Social housing is much more important in areas with relatively good housing but high poverty, compared with areas with poor housing but low poverty. Warm Homes work in areas with high levels of problematic housing typically help properties which have energy costs, which are about 12% higher than the properties that are helped in those areas which have lower levels of problematic housing, but high levels of poverty.

This strongly suggests that any policy targeting fuel poverty should be targeting rural areas in order to achieve success, and in particular, it should be targeting small villages, hamlets and open countryside.

Warm Homes Scheme

17.12 The Northern Ireland average cost of work on the Warm Homes Scheme in recent years is £1490, and an average SAP improvement of 9.8 points has been recorded. There is a considerable variation, however, between Belfast Metropolitan Urban Area and small villages, hamlets and open countryside. The cost of improving the housing stock in the most rural of areas is likely to be about 80% more expensive than improving stock in Belfast (or 37% more expensive than the Northern Ireland average).

Insulation measures have a similar cost in both owner-occupied and private rented sector, rising by 33% over five years to £670. The cost of heating measures installed has diverged by sector. The cost in 2006-07 was about £3,800 in both sectors. Whilst the value of work on private rented properties remained the same, it increased by 31% over five years for owner-occupied to about £5,000.

Much of the variance of average local cost of works under Warm Homes can be explained by thirteen local variables found to be statistically significant. The model suggests the basic cost is reduced for units in Belfast, Derry and in areas with higher levels of gas uptake, oil price, social housing, owner occupation, room occupancy (households in mid life cycle, smaller houses) and population density (urban vs rural). Spending is greater for units in those areas with higher levels of detached housing, terraced housing, room numbers (bigger houses), older people and annual degree-days (colder areas).

Low energy efficiency (ie high energy cost), low density of settlement (Ie greater distance between houses) and high poverty are associated with higher costs of work. Greater availability and use of gas boilers, higher oil prices and colder climate (ie higher number of degree-days) are associated with cheaper work. The lowest cost of work is found in the Belfast Metropolitan Urban Area, where gas is available, settlement is dense and poverty is low, while energy efficiency is good, oil price is high and climate is warm. Highest costs are in small villages, hamlets and open country, where gas is not available and settlement is sparse (though poverty is low). Energy efficiency is poor, oil price is low and climate is cold. There is therefore a strong geographical link to the costs being incurred, with poor housing and absence of gas in cool rural areas.

17.13 Applying the local cost of intervention to the estimated local numbers in fuel poverty suggests that the total cost of a retrofit for every house containing a fuel poor household, at recent prices, would be about £454 million for Northern Ireland as a whole. It is an estimate broadly in line with the estimate derived from the CES data This level of expenditure would probably not be sufficient to achieve an ideal target SAP rating of 85 for the units improved.

Applying these results to the CES estimate of £1,800 per improvement (2008 prices), it would be reasonable to assume expenditure of £1350 per unit in Belfast and £2450 in small villages, hamlets and open countryside. On a more substantial grant of £6,500, these prices would be £5305 and £7883, with a total cost of £1.72 billion to cover 87% of properties with a household in fuel poverty.

If it is assumed that the objective is to improve units to a target SAP rating of 85, and further assumed that the cost per SAP unit gained remains constant, then if all properties in need of improvement have a SAP in the range 40-50, as was the case historically (see Table 10.2), the total cost of improvement is in the neighbourhood of £1.93 billion.

Boiler installation

17.14 According to NIHE supplied data on the period 2002-2009, Warm Homes installed almost 15,000 boilers, principally in the owner-occupied sector. Of these, about 87% were oil boilers. Gas boilers were installed principally in Belfast Metropolitan Urban Area (44% of all installations compared with 5% or less in other urban areas and virtually none in rural areas). The mean cost of the installations was about £1,450 (slightly more in rural areas and slightly less in urban). This suggests a current cost of about £1,785, suggesting a substantial saving through bulk purchase (current costs quoted by Energy Saving Trust are 22% higher).

There is a significant and substantial correlation between the proportion of gas boiler installations in an area and the cost of boiler work (greater where there are more gas installations), initial energy costs of housing, cost of Warm Homes interventions and dispersal of housing (all are less where there are more gas installations ie in Belfast). The cost of boiler installation is higher in the areas where initial fuel costs are higher. Initial energy cost is higher in the areas where the cost of Warm Homes intervention and dispersal of housing is higher. Cost of Warm Homes intervention is higher in areas where dispersal of housing is higher.

Among properties and households in areas with fuel poverty problems, just under a quarter of properties have a boiler aged under ten years old. Many households do not know the age of their boiler. Knowledge of the service record of boilers is not good. There is much use of pre-payment for fuel and many household incomes are very low.

The proportion of properties with boilers of unknown age is higher amongst properties built 1945-1984, compared with both properties built before 1919 and properties built 1991-1999. The lowest proportions of boilers aged under ten years (20-30%) are found in properties built in the period 1945-1999. Higher proportions are found in pre-war properties (33-35%) and properties built after 1999 (ie themselves aged no more than 12 years old). The proportion of boilers known to be eligible for replacement grant (ie aged over 15 years) is about 40% in all ages of property save those built after 1999, where the proportion drops to near zero.

It seems likely that older properties have undergone a retrofit with modern kit being installed when this happens, while post-war properties have experienced a drift into obsolescence retaining the kit installed at construction. Total absence of something like central heating is probably a more powerful incentive to action than dwindling efficiency of an existing system.

17.15 Possibly as many as 40% of pre-2000 properties have boilers aged over 15 years. As there were about 630,000 occupied properties in 2001-02, there could be as many as 250,000 boilers eligible for replacement grant. This compares with the approximately 15,000 boilers installed by Warm Homes over a seven year period. Even if a radical discount is made of the number of boilers eligible for replacement (to 150,000), replacing them would take about 70 years to achieve, at a total cost of £267.8 million at 2012 prices (£3.8 million per annum).

Retrofit and SAP

17.16 The cost of retrofit interventions can vary widely, with a radical retrofit considerably more expensive than a standard retrofit, even when the cost of rehousing the occupants for the duration of the work is excluded. Savings can be as much as 80% of energy costs, but with long or very long payback periods. Achieved improvement can be 25-30% less than anticipated. Building energy performance is not well understood and there is a need to establish how buildings actually work. Findings suggest that the whole of a building is not simply the sum of the parts. Since it is people who use energy, it is important to understand occupant behaviour, although "take-back" may be a cover for failure of the technology to deliver as there is no evidence of change in the temperatures to which houses are heated. The discrepancy between recorded consumption of energy at the macro-level and aggregated estimates of consumption at the micro-level may have come about from a number of causes, including the failure of energy efficiency measures to deliver the anticipated improvements.

NI data suggests that the cost per SAP point of improvement increases as the initial SAP increases but the achieved SAP improvement decreases. There is increased SAP improvement associated with decreased cost per SAP point.

Costs could be of the order of £400 for loft insulation, £3,000 for cavity wall insulation and £16,600 for internal wall insulation

SAP improvements and energy savings

17.17 In 2006, about 42% of households in houses with SAP rating of under 64 (ie below proposed minimum acceptable) were in fuel poverty, compared with 10-17% for those in houses with higher SAP In 2009, nearly half of the households in the lowest banding were not in fuel poverty. This means that targeting houses for improvement by SAP rating alone will have a considerable level of redundancy.

Given the level of local variation in climate, it seems reasonable to adjust the NI minimum and recommended SAP levels to take account of local climate (district degree days). Omagh and Magherafelt have substantially more cold properties, and Craigavon and Belfast have notably less.

When local SAP rating is used, 41% of households below minimum SAP are in fuel poverty, with 16-18% for households in warmer houses.

Based on improvement of targeted properties to local SAP standards, expenditure of about £663 million would be needed.

Benefits of retrofit

17.18 The impact of the proposed programme in terms of reducing energy costs (and to a large extent, of reducing energy consumption) could be quite considerable. The reduction in costs would vary from 9% in Castlereagh to 32% in Larne, with an overall reduction of 19% for the whole of Northern Ireland. This seems plausible since the programme would be targeting about 30% of the NI occupied housing stock with the aim of reducing their estimated energy costs (UK prices) by over 50%. The targeted properties probably account for about 40% of NI's estimated energy costs.

17.19 The cost of creating a public sector sponsored job is about £35,000 and Northern Ireland might hope to secure 1,400 jobs providing 27,800 treatments. This would take over ten years to cover all households, and cost £534,200,000 (say £50,000,000 per annum at 2008 prices).

17.20 There are on average 508 Excess Winter Deaths per annum in Northern Ireland and a further 462 temperature related deaths outside the winter period. Caution is required in extrapolating results derived from English experience to the Northern Ireland situation. It is likely that in many English local government areas, Excess Winter Deaths form a much higher proportion of temperature-related deaths than is the case in Northern Ireland (a higher proportion of cold weather occurs in winter).

It has been found for older people (65 and over), excess winter morbidity is 70% higher in areas of high fuel poverty risk. Provision of central heating is associated with better physical functioning and general health, with significantly less chance of heart disease or high blood pressure. Insulation interventions for houses with asthmatic children resident were associated with halving of poor health, fewer days off and reduced use of medical services. Similar effects, though less marked, were recorded from installation of non-polluting heating sources looked at reductions in asthma following insulation and found indications that better cost benefit results were obtained from applying basic interventions than from targeted intervention to improve existing insulation and from untargeted intervention. This suggests that the law of diminishing returns is applicable here, as in most interventions.

17.21 A rough calculation in respect of Northern Ireland suggests that if the number of gas customers increased by 12.7% (average annual growth rate over the period 2005-2010), the switch of about 18,400 customers from non-gas, non-electricity to gas would reduce carbon generation by 1.75%.

Response of Recipients

17.22 It is however possible to become over-concerned with the work programme rather than the beneficiaries. It is important to remember that the response of recipients is dependent on their interpretation of their experience, not on the original intentions of those making the intervention. Energy use can increase as a response to some efficiency changes and decrease with others.

Despite their original motivation, the tenants can find the retrofit process difficult and disruptive. This seems something that likely to reduce motivation.

Quality of building construction plays only a limited role in determining an actual energy performance in domestic buildings. Households can use three or more times as much energy for heating as their neighbour, even if they live in identical homes and sufficient deviation in comfort temperatures should be allowed after a retrofit, more than what the standards of conventional comfort theory may indicate.

It is very hard to estimate standard energy consumption for even identical buildings in simulations for policies related to retrofit. Lifestyle changes have been found to be more effective. Policy instruments such as FIT and Smart Meters are based on the rational choice models that assume that people make rational decisions, but in practice, there seems to be irrational economic behaviour, although it may well not be irrational in terms of other, non-economic, considerations.

Increasing consumption is not however necessarily economically irrational, as the installation of energy efficiency measures alters the calculus of value for money. Those in poor quality houses have the greatest incentive to increase consumption and the greatest capacity to do so.

In the Northern Ireland context, given its climate and housing market, it is likely that a price premium of about 30% applies between the worst and the best properties in energy performance terms. The robustness of this estimate is weakened by the impact of detached countryside properties which amount to 18% of NI households (cf 5% of English sales).

Targeting Fuel Poverty

17.23 The BRE Fuel Poverty model takes account of differences in regional climatic conditions, but there is no evidence that any adjustment is made for sub-regional variations (eg heat islands, altitude, exposure) which can be quite as great. Where sub-regional data exists, it is appropriate to take some account of this.

The average target rating of small areas, analysed by district council, where target rating is computed from the number estimated to be in fuel poverty, adjusted by the ratio of local annual degree-days to Northern Ireland annual degree-days. Omagh and Strabane have the highest rating (95 and 93, respectively) compared with Carrickfergus and North Down (45 and 43, respectively) and a Northern Ireland rating of 61. Between North Down and Ballymoney (84), there is a fairly regular increase in rating for district councils, but Omagh and Strabane stand alone, markedly worse off than Ballymoney.

18 DEVELOPMENT OF A PLAN

18.1 The development of a plan is not a linear process. It starts with the identification of broad objectives, including the level of resources which it is initially proposed to devote to the achievement of the planned objectives[30]. The next stage is the identification of real world constraints on achieving the objectives, followed by the proposal of means to overcome these constraints. This quite often requires modification of the objectives[31], and this modified objective will very likely encountered modified constraints, which in turn require modified proposals on means to overcome them. The cycle continues until there is a satisfactory match between objectives and plans.

18.2 The broad objective of the Bryson Energy work is to address issues of fuel poverty through retrofit interventions to improve the quality of housing stock in Northern Ireland. There is no indication of the resources that it is intended to devote to the project. An expenditure of £5 on energy saving light bulbs and an expenditure of £500 million on deep retrofits equally meet the objective as stated.

18.3 There is thus a need to clarify what resources are available, and precisely what objectives are being sought. The more that is attempted, inevitably the greater the cost. Table 18.1 illustrates the degree of variation that is possible. There is an almost tenfold variation in cost, from undertaking the replacement of 150,000 boilers at perhaps £268 million (all prices are somewhat tentative) to raising to a value of 78, the SAP of over 300,000 houses occupied by the fuel poor at around £2,043 million.

18.4 Eliminating fuel poverty is an ambitious target, and as noted in section 1, fuel poverty is a household characteristic, while poor housing stock is a concept relating to houses. Not all fuel poor households necessarily live in poor housing stock and not all poor housing stock necessarily contains fuel poor households, with the result that improvements to some better housing stock are required in order to achieve success. Some expenditure directed towards improvement of the housing stock (a desirable end in itself, though not the primary purpose of the work) will not immediately assist the fuel poor, although it will reduce the likelihood that a poor household moving into another house will enter into fuel poverty as a consequence of the move.

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[30] To will the end without willing the means is an exercise in futility (see Kant, 2004, 18 on subject).

[31] It may well be that the objective is impossible as it stands. In particular, the suggested resources may be inadequate to achieve their intended purpose, but there may also be other problems.

Table 18.1 Consolidation of estimated costs of various Interventions

Intervention	Section	Properties (000)	Total Cost (£ million)	Cost (£) per intervention
Boiler installation	11.1	150	268	1,787
Warm Homes costs, retrofit for those in fuel poverty	10.4	297	454	1,529
Cambridge Economic Services (2008 prices)	14.2	296	534	1,804
Houses of Local Fuel Poor raised to local standard of SAP	13.4	209	664	3,177
Raising SAP to 78 for 87% of the Fuel Poor	10.5	258	1,720	6,667
Raising SAP to 78 for all Fuel Poor	10.6	314	2,043	6,506
Raising SAP to 78 for all properties	10.7	721	2,376	3,293

Source: Sundry Sections of the Report

18.5 Annex 9 shows some tool kits that might be used in the development of detailed plans. It suggests that considerable caution should be exercised in their use, as they use Great Britain or English data, even when labelled as 'UK'. Consideration needs to be given to whether this may be appropriately extrapolated to a Northern Ireland context. Sometimes, it may be appropriate, but frequently, it will not be appropriate.

18.6 Any plan that is developed should therefore be validated though an appropriately designed pilot, in order to establish that assumptions made during design are justified. Such a pilot should address perhaps five different scenarios which should include as the two extremes: western upland open countryside pre-1919 detached property (off gas network, deep retrofit required – possibly a bungalow in rural Omagh District) and eastern coastal urban post 1945 terraced property (on gas network, light retrofit needed – possibly a former Housing Executive terrace house in Belfast District). At least three intermediate scenarios should also be examined, such as an older (pre-1945) terrace house in a large town or Derry/Londonderry, a post-1945 semi-detached suburban house in the Belfast Metropolitan Urban Area and a pre-1945 detached house in a small or medium town. Other intermediate scenarios could be devised as needed.

Recommendation

pilot any proposed retrofit plan, before finalization, so that issues and problems can be explored, as well as identifying the level of achievable improvements Such a pilot should address perhaps five different scenarios

19 RECOMMENDATIONS

19.1 The various recommendations made throughout the report are presented in the rest of this section, together with a brief statement of the rationale.

19.2 *Policy makers should take account of the fact that fuel poverty is not solely a function of household energy efficiency any more than it is solely a function of household income*. Social housing, though housing a high proportion of the poorest families, is often not the worst quality housing, having been built and maintained to higher standards than are universally applied in the private sector. The use of benefit passports will exclude some of the fuel poor, particularly in rural areas where self-employment is common.

19.3 Retrofit policies and plans need to be set in their local context, in the awareness that what works in one place may not work in another. Accordingly, *policy makers should seek to ensure that their plans are validated for the Northern Ireland context.*

19.4 Government policies are numerous, disparate and sometimes contradictory. Where the opportunity arises, *policy makers should advocate and facilitate the co-ordination of government policies on an inter-departmental basis*.

19.5 Given the identifiable differences in circumstances within Northern Ireland, *policy makers should seek to develop their plans so as to make them appropriate to varying sub-regional and local conditions*. For example, a programme of replacing oil boilers with gas boilers is only feasible in towns, cities and villages served by the gas network, and cannot help other households, often in greater need, in rural areas. An alternative programme of work is required to assist such rural households

19.6 In all aspects of the retrofit project, *policy makers should take account of climatic variability, since climate is the basic driver of heating need*. Northern Ireland differs from many other parts of the UK, and indeed average English climate cannot be used as a reliable guide to heating need in individual English regions. Within Northern Ireland, there is significant variation in climate.

19.7 *Policy makers should take account of the prevalence of less easily heated property in rural areas*. Since it would be inappropriate to deny assistance to those applicants who on the basis of their personal and property characteristics might be deemed eligible, wherever they may happen to live, it may be appropriate to address this through targeting of publicity.

19.8 *Policy makers should advocate, as opportunity arises, the improvement of statistics on energy utilities*, since a good knowledge of the energy sector is required in order to understand the environment in which they are operating. Considerations of commercial and statistical confidentiality should be given relatively low priority, given that the gas and electricity market is a state-sponsored oligopoly, rather than a free market.

19.9 *Policy makers should take account of the impact of the computational changes made for presentational reasons in the conversion of Energy Cost Factors into SAP ratings*. This renders comparisons of SAP ratings indicative rather than definitive (eg the Energy Cost Factor of a SAP 20 property is 4.7 times that of a SAP 80 property, not 4.0 times as might be deduced from the SAP values)

19.10 *Policy makers should set Northern Ireland specific SAP targets (possibly: minimum acceptable SAP 64, recommended SAP 78, ideal SAP 85)*. The minimum might be further appropriately adjusted to reflect district council local climatic conditions (see Table 13.4).

19.11 *Policy makers should seek to be sensitive to the needs and wishes of the owners and occupants of housing identified as suitable for retrofit*. This will probably involve providing advice on options available for improvement, minimising paperwork and facilitating their convenience (which may require targets that do not concentrate solely on the progress of construction and project management). The impact of energy performance enhancements on property value should not be neglected in dealing with owners.

19.12 *Policy makers should pilot any proposed retrofit plan, before finalization, so that issues and problems can be explored, as well as identifying the level of achievable improvements. Such a pilot should address perhaps five different scenarios*.

19.13 Table 19.1 summarises the above recommendations for Policy makers.

Table 19.1 Recommendations for Policy makers in developing a retrofit policy and plan for Northern Ireland

Number	Section	Recommended measure for Policy makers to adopt
1	1	*take account of the fact that fuel poverty is not solely a function of household energy efficiency any more than it is solely a function of household income*
2	2	*seek to ensure that activities are validated for the Northern Ireland context*
3	3	*advocate and facilitate the co-ordination of government policies on an inter-departmental basis*
4	4	*seek to develop plans so as to make them appropriate to varying sub-regional and local conditions*
5	4	*take account of climatic variability, since climate is the basic driver of heating need*
6	6	*take account of the prevalence of less easily heated property in rural areas*
7	6	*advocate, as opportunity arises, the improvement of statistics on energy utilities*
8	13	*take account of the impact of the computational changes made for presentational reasons in the conversion of Energy Cost Factors into SAP ratings*.
9	13	*set Northern Ireland specific SAP targets (possibly: minimum acceptable SAP 64, recommended SAP 78, ideal SAP 85)*
10	15	*seek to be sensitive to the needs and wishes of the owners and occupants of housing identified as suitable for retrofit*
11	18	*pilot any proposed retrofit plan, before finalization, so that issues and problems can be explored, as well as identifying the level of achievable improvements Such a pilot should address perhaps five different scenarios*

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ANNEX 1

National Taxation and Expenditure in Northern Ireland

National taxation is a reserved matter, over which Northern Ireland, as a devolved administration, has no control. These matters are determined centrally (often with relatively little regard to regional effects, and even less to the impact on devolved administrations, as the recent prolonged and apparently nugatory discussions relating to Corporation Tax in Northern Ireland demonstrate). The formula for attributing the proceeds of taxation to Northern Ireland is at best notional, and of limited significance since Northern Ireland spends more public money than it raises, hence receives a further block grant from HM Treasury. Of greater significance is the Barnett formula (also simplistic) which allocates additional money to the block grant available for a devolved administration, in line with increased spending in England, on the basis of the ratio of population in the territory to English population. This additional money need not be spent in Northern Ireland on the policies which prompted the increased spending in England (although the devolved administration will often chose to do so, if it is considered appropriate to maintain parity with Great Britain.

ANNEX 2

Peat in Ireland

Of coal, oil, natural gas and peat, peat is the nearest to a renewable energy source. In Ireland, the bulk of the peat formed in raised bogs on the lowlands, in the period 8-5,000 BC with blanket bogs forming in highland areas from about 3,500 BC onwards (see Connolly 200, 53). Since the start of the sub-Atlantic climatic period (500 BC to present), cold wet conditions have facilitated the more rapid formation of peat. Nonetheless, the current rate of depletion far outweighs the ability of Irish bogs to replenish themselves. Peat has half the calorific value of coal, but similar bulk.

ANNEX 3

Northern Ireland environment for Solar Warming Kit

There is a great variety of solar warming and photovoltaic kit available. This is effective in the Northern Ireland environment, but it should be borne in mind that there can be a great deal of difference in that environment, dependent on its orientation. Table A3.1 shows that in an area of Scotland with latitude and climatic conditions similar to Northern Ireland, there can be very substantial variation in the duration and extent of insolation.

T**able A3.1 August mean temperature and hours of insolation in Galloway**

Wall	**Mean August temperature (C)**	**Hours of insolation**
North	22.2	9
East	16.7	7
West	16.7	7
South	12.8	2

NB The North Wall is south-facing and the East Wall is west-facing. Similarly for the other walls

Source: National Trust monitoring of walled garden, Threave Gardens nr Castle Douglas Galloway

ANNEX 4

Warm Homes data supplied to University of Ulster

Table A4.1 shows the nature of the data supplied to University of Ulster concerning 81,311 Warm Homes interventions (See Walker, Liddell, McKenzie & Morris, 2013). It will be seen that the only data available for all interventions is postcode. This makes comparison throughout the period impossible at an individual level. It is not known why the data changes so much from year to year.

A single integrated record was assembled for all interventions holding the data recorded and assigning a missing value for those items not recorded in the year of intervention. Postcode was used to assign a Census Output Area to each intervention, as analysis at postcode level would be based on a NI average of about 1.5 interventions per postcode.

From Census Output Area, which is still rather small (a NI average of about 16 interventions per COA), Ward can be deduced and a Ward average was calculated for cost, pre-intervention SAP and post-intervention SAP. This Ward average was appended to other data such as local degree-days and settlement type.

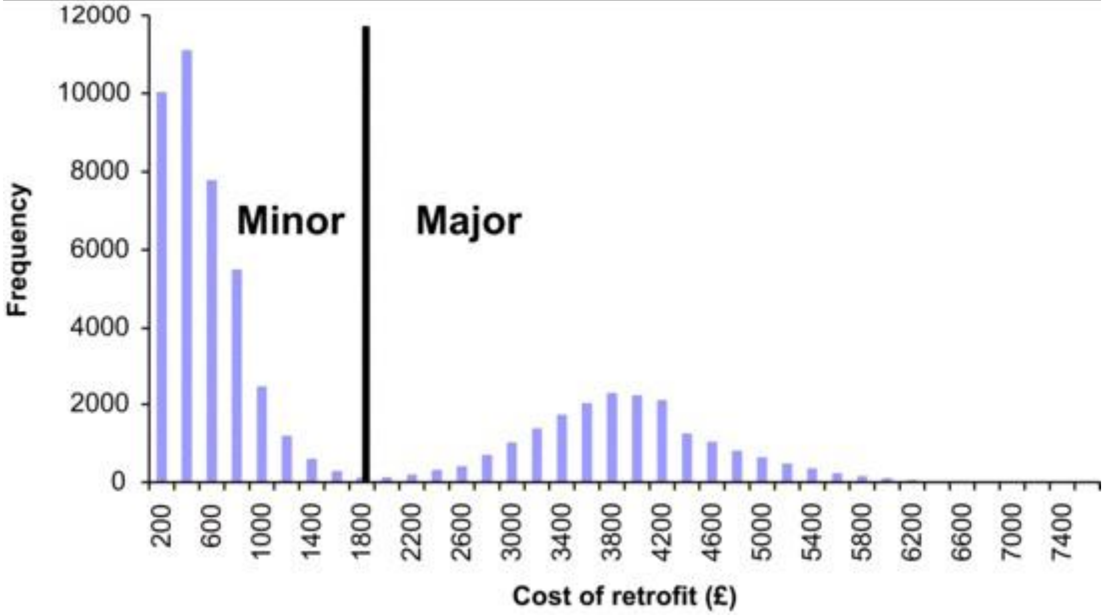
Table A4.1 Data supplied on Warm Homes interventions by year

Pre-2009	2009-10	2010-11	2011-12
Postcode	Postcode	Postcode	Postcode
Recipient Date of Birth	Pre EPC	Pre SAP	Pre SAP
Tenure	Post EPC	Post SAP	Post SAP
Number of Measures	Contractor	Contractor	Contractor
Cost		CWS & Pipework	
		Loft Insulation	
		CWI	
		HWTJ	
		Oil heating	
		Gas heating	
		Any heating	
		Hard to treat	
		Number of Measures	

Source: Walker, Liddell, McKenzie & Morris, 2013

Table A4.2 shows that the cost of work undertaken is bimodal, with Minor works common, with 11,000 cases at about £400, and Major works with about 2,000 cases at £3,800. Very few cases cost about £1,800, which may be taken as the boundary between Minor and Major retrofits.

Table A4.2



Source: Walker, Liddell, McKenzie & Morris, 2013

ANNEX 5

Regression to explain Average Local Cost of works under Warm Homes Scheme

Dependent Variable: Local Average Cost of Works
Predictors: (Constant), Gas uptake, Belfast, Percent Detached property, Derry, Oil price, Annual Degree Days, Age 65 plus, Population Density, Average Room Occupancy, Percent Social Housing, Percent Terraced property, Percent Owned, Average No Rooms

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.551	0.303	0.303	321.4773
2	0.581	0.337	0.337	313.5917
3	0.603	0.363	0.363	307.4491
4	0.614	0.377	0.376	304.221
5	0.632	0.399	0.399	298.6369
6	0.638	0.407	0.406	296.7226
7	0.641	0.411	0.410	295.8075
8	0.643	0.413	0.412	295.3483
9	0.644	0.415	0.414	294.8025
10	0.646	0.417	0.416	294.3082
11	0.647	0.419	0.418	293.8504
12	0.648	0.420	0.419	293.6682
13	0.649	0.421	0.419	293.5754

Coefficients					
Model 13	Unstandardized Coefficients B	Std. Error	Standardized Coefficients Beta	t	Sig.
(Constant)	3799.728	261.000		14.558	.000
Gas uptake	-175.991	19.810	-.178	-8.884	.000
Belfast	-178.135	15.401	-.223	-11.566	.000
Percent Detached	1.734	.337	.144	5.150	.000
Derry	-331.869	24.116	-.179	-13.762	.000
Oil Price	-14.751	1.196	-.174	-12.332	.000
Annual Degree Days	.368	.046	.108	8.030	.000
Age 65 plus	3.928	.686	.076	5.723	.000
Population Density	-1.231	.208	-.104	-5.913	.000
Average Room Occupancy	-100.529	27.795	-.127	-3.617	.000
Percent Social Housing	-2.610	.480	-.127	-5.434	.000
Percent Terrace	.924	.269	.063	3.437	.001
Percent Owned	-1.522	.580	-.087	-2.624	.009
Average Rooms	32.217	16.397	.078	1.965	.049

Source: Warm Homes

ANNEX 6

Simplified regression to explain the cost of Warm Homes work

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.548	.300	.300	321.859211683
2	.626	.392	.392	299.957081483
3	.651	.424	.423	292.118187393
4	.666	.443	.443	287.209497451
5	.671	.451	.450	285.235271957
6	.672	.451	.451	285.110180512
Model 1. Predictors: (Constant), Boiler Gas Proportion				
Model 2. Predictors: (Constant), Boiler Gas Proportion, Average inter-house distance				
Model 6. Predictors: (Constant), Boiler Gas Proportion, Average inter-house distance, Initial Energy Cost Factor, Oil price, Poverty, Annual Degree Days				

Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
6	(Constant)	3277.563	223.297		14.678	.000
	Boiler Gas Proportion	-553.520	18.127	-.398	-30.536	.000
	Average inter-house distance	.448	.027	.252	16.500	.000
	Initial Energy Cost Factor	181.860	9.853	.230	18.457	.000
	Oil price	-11.804	1.025	-.140	-11.516	.000
	Poverty	3.978	.497	.091	8.010	.000
	Annual Degree Days	-.108	.048	-.031	-2.227	.026

Stepwise linear regression

Dependent Variable: Cost of Warm Homes Work

No Excluded Variables

Source: data on small areas from NIHE, Warm Homes and ABA databases

ANNEX 7

Multinomial Logistic Regression to explain boiler type in houses visited by ABA

Variables entered

Dependent: boiler type (gas, non-gas less than 5 years old, non-gas not known to be less than 5 years old).

Independent: House type, electricity pre-payment, tenure, rurality, house age, window glazing, house size (floor space), income

The stepwise regression did not find window glazing, house size or income significant in explaining the boiler type. House type, electricity pre-payment, tenure, rurality and house age were significant.

Compared to households with gas boilers, households with new (less than 5 yrs old) oil boilers are:

- Somewhat more likely to be in newer houses
- Somewhat more likely to be owner occupied than private renting
- Somewhat likely to be detached or semi-detached than terraced
- 2.64 times more likely to pay for electricity using direct debit or cheque rather than pre-payment
- Significantly more likely to be in rural areas than urban

Compared to households with gas boilers, households with older (5 or more yrs old) oil boilers, oil boilers of unknown age, boilers using fuels other than oil or gas, or no boilers are:

- Somewhat more likely to be newer houses
- Somewhat less likely to be owner occupied than private renting
- 2.09 times more likely to be detached or semi-detached than terraced
- 2.14 times more likely to pay for electricity using direct debit or cheque rather than pre-payment
- Significantly more likely to be in rural areas rather than urban

Case Processing Summary			
		N	Marginal Percentage
Efficiency of boiler	Natural Gas Boiler (any age)	64	4.2%
	Not Gas Boiler (Known 0-5 years)	177	11.6%
	Not Gas Boiler (Not 0-5 years)	1279	84.1%
House Type	Terraced	847	55.7%
	Detached/semi	673	44.3%
Pays electric by prepayment	No	645	42.4%
	Yes	875	57.6%
Household Tenure (Owner occupied/private rent)	Owner Occupied	1214	79.9%
	Private Renting	306	20.1%
Valid		1520	100.0%
Missing		579	
Total		2099	
Subpopulation		1520[a]	

a. The dependent variable has only one value observed in 1520 (100.0%) subpopulations.

Step Summary							
Model		Action	Effect(s)	Model Fitting Criteria	Effect Selection Tests		
				-2 Log Likelihood	Chi-Square[a,b]	df	Sig.
Step 0	0	Entered	Intercept	1608.255	.		
Step 1	1	Entered	Rurality	1425.900	182.355	2	.000
Step 2	2	Entered	Tenure	1412.654	13.246	2	.001
Step 3	3	Entered	House Age	1404.306	8.348	2	.015
Step 4	4	Entered	Electricity Pre-Payment	1396.595	7.711	2	.021
Step 5	5	Entered	House Type	1389.599	6.996	2	.030

Stepwise Method: Forward Stepwise

a. The chi-square for entry is based on the likelihood ratio test.

b. The chi-square for removal is based on the likelihood ratio test.

Model Fitting Information				
Model	Model Fitting Criteria	Likelihood Ratio Tests		
	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	1608.255			
Final	1389.599	218.656	10	.000

Pseudo R-Square	
Cox and Snell	.134
Nagelkerke	.205
McFadden	.136

Likelihood Ratio Tests

Effect	Model Fitting Criteria	Likelihood Ratio Tests		
	-2 Log Likelihood of Reduced Model	Chi-Square	df	Sig.
Intercept	1389.599[a]	.000	0	.
House Age	1396.417	6.818	2	.033
Tenure	1400.216	10.617	2	.005
House Type	1396.595	6.996	2	.030
Electricity Pre-Payment	1397.416	7.817	2	.020
Urban-Rural	1562.600	173.001	2	.000

The chi-square statistic is the difference in -2 log-likelihoods between the final model and a reduced model. The reduced model is formed by omitting an effect from the final model. The null hypothesis is that all parameters of that effect are 0.

a. This reduced model is equivalent to the final model because omitting the effect does not increase the degrees of freedom.

Parameter Estimates

Efficiency of boiler[a]		B	Std. Error	Wald	df	Sig.	Exp(B)	95% Confidence Interval for Exp(B)	
								Lower Bound	Upper Bound
Not Gas Boiler (Known 0-5 years)	Intercept	-4.470	.923	23.454	1	.000			
	House Age	.212	.220	.931	1	.335	1.236	.804	1.901
	Tenure: OO	.217	.435	.250	1	.617	1.243	.530	2.915
	Tenure: PR	0[b]	.	.	0	.	.	.	.
	House Type: D/SD	.419	.381	1.212	1	.271	1.520	.721	3.205
	House Type: Terr	0[b]	.	.	0	.	.	.	.
	Electricity PP: No	.972	.356	7.455	1	.006	2.642	1.315	5.307
	Electricity PP: Yes	0[b]	.	.	0	.	.	.	.
	Rurality	1.721	.250	47.563	1	.000	5.592	3.429	9.121
Not Gas Boiler (Not 0-5 years)	Intercept	-2.087	.835	6.256	1	.012			
	House Age	.365	.208	3.083	1	.079	1.441	.958	2.166
	Tenure: OO	-.520	.356	2.131	1	.144	.595	.296	1.195
	Tenure: PR	0[b]	.	.	0	.	.	.	.
	House Type: D/SD	.735	.345	4.525	1	.033	2.085	1.059	4.104
	House Type: Terr	0[b]	.	.	0	.	.	.	.
	Electricity PP: No	.763	.322	5.620	1	.018	2.144	1.141	4.029
	Electricity PP: Yes	0[b]	.	.	0	.	.	.	.
	Rurality	1.657	.246	45.552	1	.000	5.244	3.241	8.486

a. The reference category is: Natural Gas Boiler (any age).

b. This parameter is set to zero because it is redundant.

Note: House Age: scaled 1-5 (1=pre-1919, 5=post-1985) Tenure: OO: owner occupied (own outright + buying on mortgage), PR: private renting
House Type: 0=detached/semi-detached, 1=terraced
Electricity PP: Electricity pre-payment - No (Direct Debit or Cheque), Yes (prepayment)
Rurality: scaled 1-6 (1=BMUA, most urban, 6=SVHOC, most rural).

ANNEX 8

Regression of Excess Winter Deaths in England against location, rurality and fuel poverty for local government areas

Dependent Variable: Excess Winter Deaths(1991-2010) in England per 100,000 population

Predictors: Percentage Fuel Poverty, North, East, Percentage Rural Population

R	R Square	Adjusted R Square	Std. Error of the Estimate		
.438	.192	.182	19.97452		
Variables	**Unstandardized Coefficients**		**Standardized Coefficients**	**t**	**Sig.**
	B	Std. Error	Beta		
(Constant)	15.010	6.200		2.421	.016
Percent Fuel Poverty	2.681	.390	.539	6.878	.000
North	-9.594	3.192	-.216	-3.006	.003
East	6.224	2.635	.132	2.362	.019
Percent Rural	.076	.033	.122	2.293	.022

Source: ONS mortality statistics

ANNEX 9 Three Tools Available for use in planning, with comments

There are a number of website-based computational tools available for planning purposes. It is important to remember in using any such tools that even the best-designed and supported computer programme will yield inappropriate results when data derived from one environment are extrapolated and applied to data derived from a different environment (see the results of Annex 8 and comments at 14.15 as an illustration of this).
Three computational tools are:

1. Centre for Sustainable Energy: Housing Energy and Poverty Assessment Tool

   http://www.cse.org.uk/projects/view/1144

   This allows an estimate, originally based on the English Housing Survey, of local levels of fuel poverty. It uses Great Britain data. Data and model must be acquired separately

2. Energy Savings Trust: Housing data and Analysis

   http://www.energysavingtrust.org.uk/Organisations/Local-delivery/Home-Analytics-housing-data-and-analysis

   The use of this model may involve some expense in installing supporting software packages. It utilises a probabilistic attribution of property facilities, based on Great Britain data (Northern Ireland Ordnance Survey data is not included). The 'UK' Housing Survey that is used is in fact derived from Great Britain housing surveys.

3. Chartered Institute of Environmental Health: Housing Health Calculator

   http://www.cieh.org/policy/good_housing_good_health.html

   This estimates the NHS costs incurred through treating cases arising from damp and mould (£200-£2,000) and excess cold (£100 - £22,300), as well as other housing related health events linked to radon, falls, fires, hot surfaces and building collapse. These costs are English.

Care is needed in determining whether the data here is appropriate. There is no particular reason to suppose that English NHS costs differ radically from Northern Irish NHS costs (Chartered Institute Calculator). There is considerable evidence to demonstrate that the housing and heating situation in Northern Ireland differs from Great Britain and many British regions.