Energy Policy and Consumer Hardship

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RENEWABLE ENERGY FOUNDATION

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Renewable Energy Foundation

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About the Renewable Energy Foundation

The Renewable Energy Foundation is a registered charity promoting sustainable development for the benefit of the public by means of energy conservation and the use of renewable energy.

REF is supported by private donation and has no political affiliation or corporate membership. In pursuit of its principal goals REF highlights the need for an overall energy policy that is balanced, ecologically sensitive, and effective.

We aim to raise public awareness of the issues and encourage informed debate regarding a structured energy policy that is both ecologically sensitive and practical. The issues of climate change and security of energy supply are complex and closely intertwined. REF contributes to the debate surrounding these issues by commissioning reports to provide an independent and authoritative source of information.

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About the Study

The study was funded by the ScottishPower Energy People Trust (SCO 036980).

It has been conducted by Renewable Energy Foundation researchers: Dr John Constable, Dr Lee Moroney, and Diana Beatty, with assistance from various volunteers and interns, including David Ross, Simranjit Jain, and Ava Ichaporia. We would also like to thank Hugh Sharman for conducting much of the analysis underlying our discussion of the Danish situation.

Preface: Energy and the United Kingdom Housing Stock

Energy is on the national agenda in a way that it has not been for decades. There are concerns about the security of energy supply, as we now import more energy than we export after a thirty year bonanza from the North Sea. Energy prices are rising on global markets because of the sharp increase in energy demand from advancing economies, especially China. The long-term depletion of non-renewable sources of energy is always in the background, and concerns about resilience to future climates also feature in the public debate.

In the UK we consume 45% of our energy in heating air and water in buildings, and 27% of all our energy is deployed in our 26 million homes. Over 90% of this energy comes in the form of coal, gas or oil, all fossil fuels that emit carbon dioxide when burned. If we are to get anywhere near the Government's target of an 80% reduction in carbon dioxide emissions by 2050, a major retrofit of the existing housing stock is essential. One quarter of our houses were built in Victorian times and another quarter after World War Two. Because we live in a Goldilocks climate (not too hot and not too cold), and because first coal and then oil was cheap during the two major construction eras, the quality of the thermal envelope of British houses was never a major issue in the design. Our housing stock is not very effective in keeping heat in, or out. Houses built in Scandinavia and Iberia had good thermal insulation in their design, and we are going to have to retrofit UK homes to match their performance.

The retrofit agenda is primarily one of scale. The total cost over the next 40 years is of order £1 trillion for the UK housing stock, or £50,000 per home. You get modest improvements today for £5,000 spent on the thermal fabric of a house, but as we approach 2050, it is harder and more expensive to get the big improvements that are ultimately necessary. I have made a study of Cambridge to show that £600 million spent over the next decade with off-the-shelf technologies could effect a 25–30% reduction in energy consumption, with a 6–8% annual payback.

The whole project makes financial sense as an energy saving measure, but there is strong reluctance and mistrust on the part of individual home owners, partly because of the hassle, and partly because of the concern at the lack of long-term guarantees against the under-performance or any unintended side-effects. Providing reassurance on these points requires that we must improve the monitoring and reporting of energy saving measures and their actual effects. It is only by gathering rigorous measured data, as distinct from over-reliance on modelled data as at present, that we will have confidence that the efficiency technologies and practices will deliver the benefits we need.

Beyond that, an outer cladding layer of 20cm of insulating material would change the face of many narrow Victorian streets of terrace houses. We need new materials technologies, new methods of installation, and much smarter controls for serious reductions in energy demand in our houses. The sector that renovates buildings today needs to be increased by a factor of about four, along with the supply chain of building materials if we are to deliver this project. The individual efforts of eco-enthusiasts will simply not get us there.

With central heating today, we can heat the whole of our house. This is a luxury which needs to be reined in, being a profligate use of energy. But we are definitely not going back to the Victorian pattern of heating only one room for the daytime use of the entire family. Our educational system assumes that children have a dedicated quiet space for homework, and increased home working is normally undertaken from a dedicated study.

We use the term "fuel poverty" to describe the condition of those who would need to spend more than 10% of their disposable income on keeping their homes warm, these people usually being the elderly, or students, or others on fixed and limited incomes, who are least able to absorb rising energy costs. The Government has targets for reducing fuel poverty but at the same time is financing the transition to a low carbon economy through higher energy bills. Thus, two desirable outcomes are in direct conflict. However this report gives a clear way of progressing by distinguishing between "risks of hardship' and "real cases of actual hardship" and acting accordingly.

Anything short of a national plan will not get us to the nirvana of an energy efficient housing stock and the elimination of fuel poverty by 2050. Such a plan is not on the horizon. In addition to the engineering elements of scale described above, we will need a form of social engineering. Over the last 40 years we have changed individual attitudes and public behaviour concerning the wearing of seat belts in cars and the elimination of smoking in public confined spaces. An energy efficient country will not come about until there is a widespread and strong conviction that any profligate use of energy is deeply antisocial.

M J Kelly FRS, FREng
Prince Philip Professor of Technology at the University of Cambridge

Report Recommendations

- At present, government energy policies are likely to become a significant contributory factor to increasing the risk of hardship across the entire population, both through direct and indirect effects on bills, and through macroeconomic effects reducing incomes and employment. The following actions would serve to reduce the severity of this effect:
- Government should avoid the funding of environmental programmes through levies increasing energy prices to consumers.
- Where such levies are retained they should not be applied to the competitive part of the energy markets, since this causes inefficiencies that may increase costs over and above the levies themselves. A preferable alternative is to apply levies to the distribution side of the energy market, which, as a natural monopoly, would lead to more transparency and potentially less distortion.
- Energy suppliers are not natural agents for delivering the fuel poverty agenda, which should be assigned to more appropriate, perhaps non-commercial, bodies, with the energy suppliers left to concentrate on their core business, the competitive supply of energy.
- Government should extend energy efficiency programmes for low income housing to buffer households against fluctuations in both energy price and income, with such measures being funded from general taxation to avoid regressive effects.
- VAT should not be charged on the levy cost component in energy bills for either domestic or industrial and commercial customers.
- Energy efficiency products and building work to install them should be exempted from VAT or 0% rated.
- Over two million households use electricity as their main source of heating, and will experience significant increases in risk of hardship due to policy-induced effects on bills. Government should encourage fuel switching to gas where possible, and to (subsidized) renewables for heat in other cases. Further measures, including direct assistance, may be required.
- The potential for district heating should be explored, particularly schemes which use waste heat from power stations, schemes which replace expensive electric heating systems, and schemes which supply commercial premises and high rise flats in areas with significant heat loads.
- Government should improve information available to householders on their energy bills related to energy policies, energy costs and potential energy efficiency savings. For example, bills should list the costs imposed on the household by environmental policies, including the contributions for grid integration and ancillary services necessary to support the climate change policies.
- Energy tariffs are opaque: at the very least bills should display the range of tariffs available. With respect to energy efficiency, bills could usefully display annual energy consumption in kWh per square metre for both the average UK dwelling and the best of UK dwellings, so that householders could estimate potential savings for improving the energy efficiency of their own dwelling.
- The Office for National Statistics should produce experimental data series based on national energy spend as a fraction of GDP, indicating clearly and analytically the fraction that results from policies, namely levies and taxes. Other similar ratios, such as household energy spending as a fraction of income, could also be reported for the various income bands with all policy impacts presented analytically.
- Any subsidised energy efficiency programme should entail mandatory reporting of outcomes, with the data made publically available to accelerate market learning and increase the up-take of the most successful measures.

- All data should be reported in a straightforward and readily accessible manner. We note that whilst there is an abundance of Government sponsored data available on energy and fuel poverty, much of it is esoteric and unelaborated, difficult to access and dispersed over several sometimes shifting locations.
- Similarly, there is an abundance of European Commission-funded statistical data on energy issues, but problems undermine its usefulness. For example, Danish figures for domestic space heating include hot water whereas the UK figures do not. Domestic electricity prices are quoted for European countries net of taxes, but national levies are not treated in the same way, so are not comparable. If such data is to be used to monitor the effectiveness of EU policies it needs to be isometric and rigorous.
- Government should employ empirical investigation to facilitate the prompt and targeted application of remedial medical and financial measures to address cases of actual hardship arising from unaffordability of energy.

Summary

The cost burden of energy and environment policies

1. The UK has a broad range of energy and environmental policies designed to meet EU climate change targets, a significant number of which are funded through levies on consumers' bills.
2. Levies affect the affordability of energy services because they have:
   a. Direct impacts increasing prices and bills,
   b. Indirect impacts increasing prices and bills (including increased energy system costs, and VAT uplift), and
   c. General macroeconomic impacts reducing employment and incomes.
3. Contemporary discussions of fuel poverty have tended to focus on the first of these, which are known to be regressive, but this study shows that there is good evidence to suggest that indirect impacts, which are also regressive, are highly significant.
4. Furthermore, we note that the macroeconomic impacts of current energy policies on employment rates and income levels have been largely neglected, with many assuming that environmental policies would create growth and jobs. However, modelling conducted for the EU Commission suggests that the net impact of current policies on the UK will be negative in terms of employment, and will imply relative economic contraction.
5. The scale of this threat is significant, since policies with direct impacts are numerous and costly. The Energy Efficiency Commitment (EEC), the Renewables Obligation (RO), the Feed-in Tariff (FiT), the Carbon Emissions Reduction Target (CERT), and the Community Energy Savings Programme (CESP) subsidies all impose costs which are passed through to consumers via electricity and gas bills.
6. Unfortunately, information on how these costs are distributed over domestic, industrial and commercial consumers is not available, and even in the case of domestic consumers it is not clear how much each of these levies adds to household energy bills.
7. Instead, we must rely on Government estimates of aggregate total cost to the consumer, both domestic and industrial. Taken together, all levy-funded measures cost £12.9 billion between 2002 and 2011.
8. The most significant policies are the Renewables Obligation, which cost the consumer £7.31 billion in the period April 2002 to March 2011, and the Carbon Emissions Reduction Target (CERT) and its related predecessor policy (EEC), which between April 2002 and October 2011 cost £5.4 billion.[1]
9. The annual costs of these or successor mechanisms are likely to rise if current policy goals are maintained. The Renewables Obligation currently costs around £1.2 billion a year but will increase steadily, and by 2020 we estimate that the RO, or its successor mechanisms under the Electricity Market Reform (EMR) package, will be costing the consumer approximately £8 billion a year.
10. The current cost of CERT is estimated by DECC to be £1.3 billion per annum and CESP approximately £70 million per annum. While CERT and CESP are due to expire in December 2012, to be replaced by the Energy Company Obligation (ECO), we anticipate that the ECO's costs will, at a conservative estimate, be similar to its predecessors.
11. DECC has predicted that the Feed-in Tariff will cost electricity consumers £570 million a year in 2020, but very rapid uptake in the first year of the scheme has given cause for concern, and recent downward revisions to the small scale solar photovoltaic FiT suggest increasing awareness that the

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[1] Lord Marland, for DECC, in answer to a parliamentary question from Lord Vinson: 25.10.11, *Hansard*, Column WA128.

policy was poorly devised and costed in the first place. Whether these revisions will contain cost to consumers is at present unclear.

12. While these levies are in themselves a significant and growing proportion of domestic energy bills, some of the source policies, particularly those affecting electricity, entail additional energy system costs that will also be passed on to consumers. Amongst these indirect impacts are the costs of ancillary electricity grid services needed to integrate the renewable technologies, including network expansion, system balancing, and the cost of maintaining a conventional fleet in the support role and at a low load factor. These costs are extremely difficult to estimate, but one authoritative analysis has suggested that the additional annual cost could be around £5bn in 2020, giving a programme cost (subsidy plus integration costs) of some £13 billion.[2]

13. Not only are these extremely high additional costs regressive in their effects, constraining household budgets and adding to general financial strain, but they are of particular concern in relation to the approximately two million households that use electricity for heating.

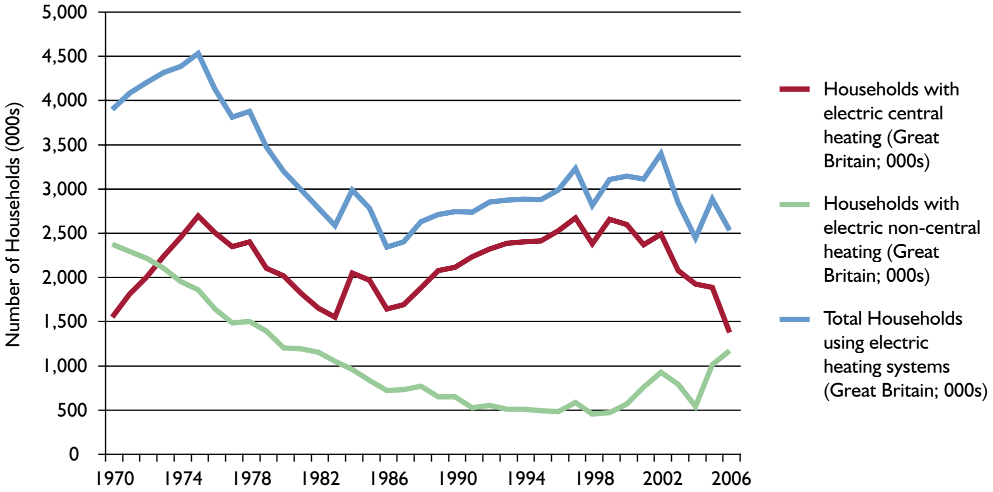

Figure 1: Households Using Electric Heating in Great Britain 1970 to 2006.
Source BRE Fact File 2008.[3] Chart: REF.

14. While the overall trend in Figure 1 (blue line) shows a reduction in the use of electric heating from the 1970s to mid-1980s, numbers have not dropped much below 2.5 million since that time, suggesting that there is a core number of houses where alternatives to electricity are hard to find.

15. We also note that there is evidence of an increase in non-central electric heating, perhaps due to the difficulties in replacing redundant non-condensing boilers in certain urban situations such as apartment blocks.

16. The renewables levies on electricity will expose households using electric heating to very significant increases in costs, and this section of the housing stock must be regarded as at high risk of hardship.

17. It should be further noted that VAT is charged on the energy levies and on the indirect costs as they are passed through to bills. This impact should be considered in any analysis of the policy impacts, since it has both straightforward effects on bills, but also broader economic impacts on the cost of living that are relevant to risk of hardship.

18. VAT registered businesses will be able to offset much if not all of the tax uplift against VAT paid on energy purchases, but VAT on the levies will make itself felt when the products or services are sold on to a final consumer that is not VAT registered, with an indirect effect on the cost of living. The

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[2] Colin Gibson, *A Probabilistic Approach to Levelised Cost Calculations for Various Types of Electricity Generation* (IESIS: Edinburgh, 2011). Available from: http://www.iesisenergy.org/lcost/.

[3] http://www.bre.co.uk/filelibrary/pdf/rpts/Fact_File_2008.pdf

scale of this uplift is hard to gauge with complete confidence, since not all these sales will be to VAT liable consumers. Nevertheless, we can estimate the potential VAT uplift on levies imposed between 2002 and 2011 at approximately £1.9bn, with about £230m being charged on domestic gas and electricity bills.

19. VAT on the Renewables Obligation alone in the period April 2002 to March 2011 could have amounted to as much as £950m, with about £130m of that figure being added to domestic electricity bills.

20. By 2020 the VAT uplift resulting from the Renewables Obligation or its successor subsidy mechanisms could amount to as much as £1.2 billion annually, with about £150m of that sum being added to domestic electricity bills, and the remainder charged to industrial and commercial consumers.

21. When additional system costs are taken into account, the total VAT uplift will amount to approximately £2 billion a year in 2020, with about £240 million of that sum being charged directly on domestic bills, with the remainder having an unclear though almost certainly significant effect on the cost of living through VAT on the sale of goods and services to end consumers.

22. It is unsatisfactory that these implicit increases in tax revenue arising from the Renewables Obligation, and other similar levies, have not been debated by Parliament.

23. It should also be noted that the direct and indirect cost burden of the energy levies falls disproportionately on poorer households, and there is every reason to suppose that the increasing number and costs of such policies has already contributed to the increase in the number of households in hardship or at significant risk. Surprisingly, answers to Parliamentary Questions reveals that Government has made no estimate of those numbers.[4]

24. In addition to these direct and indirect impacts, policies have general economic effects since levy-funded subsidies increase the cost of primary inputs to the economy, reducing economic activity and impairing competitiveness. While such subsidy policies may create jobs and incomes in the supported sector, the costs will cause job losses and reduce incomes elsewhere in the economy. Overall, though the gross effect will be positive there is good reason for supposing that the net effect may be negative.

25. Specifically, EU Commission modelling of the macroeconomic effects of the renewables policies suggests that in spite of very large gross impacts the net effects in 2020 will only be slightly positive for both GDP and employment over the EU-27. The scale of these positive effects appears to be within the measuring error, and inadequate to justify policy-induced transformation on such a scale and with such significant transition risks.

26. It should also be noted that these weakly positive effects are dependent on the EU retaining a dominant global market share in renewable energy technologies, an aspiration that appears to be optimistic given the comparative advantages of China, India, and the United States.

27. Critically, the EU modelling suggests that for certain member states, and the UK is one of them, the net employment effects in most scenarios are negative, with the costs of policies destroying more jobs than are created.

28. The relevance of general economic impacts that depress incomes is generally overlooked by fuel poverty campaigners considering policy effects and deserves much greater prominence.

29. For example, while some policies, such as the Renewable Heat Incentive (RHI) are funded through taxation, and are thus progressive rather than regressive, such measures still contribute to the macroeconomic burden, reducing employment and incomes. The potential scale of such unwanted effects

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[4] Lord Marland, for DECC, in answer to parliamentary questions 12384 and 12385 from Lord Vinson, 21.10.11, Hansard, WA104.

should not be underestimated. While the Government's Spending Review has capped the cost of the RHI in 2014/15 at £860 million, the scheme is expected to imply an annual tax burden of £2 billion in 2020, according to the Committee on Climate Change estimates.[5]

30. Overall, it is likely that UK energy policies will not only increase bills but will also tend to reduce average household incomes because of the knock-on macroeconomic effects of the various levies and taxes.

31. Given the scale of the burdens, there is reason to be concerned that the direct, indirect and general economic effects of current energy policies will significantly increase the risk of energy related hardship over the entire population, leading to a significant but intrinsically unpredictable rise in the numbers of households experiencing actual hardship.

32. Since a very large part of the burden of current policies falls on electricity consumers there is good reason for believing that the majority of the approximately two million households that use electricity for heating will be at severe risk of hardship.

Actual Hardship and Risk of Hardship

33. Current legislation, policy and much campaigning aims to eliminate "fuel poverty", as described by the current definition.[6] While expressing justifiable concern, this conceptualization of the matter has certain drawbacks, amongst the most far-reaching of which is the failure to distinguish adequately between real cases of *actual hardship* (those who are not able to purchase adequate warmth and may be living in unhealthy conditions), and the more abstract but equally important *risk of hardship*, which can be understood as the probability that a household will experience actual hardship as the result of a change of circumstances (a decline in income or a rise in energy prices, for example).

34. Indeed, the current definition of fuel poverty conflates these problems, which is unhelpful since they require responses of different characters, and success will mean different things in each case.

35. Actual hardship, where a household cannot afford sufficient heat to maintain health, or can only do so by forgoing other necessary goods or services, is an acute problem, requiring immediate action in the short term. Such problems need to be addressed and satisfactorily resolved through direct intervention by health and social services, or other means. However, reducing the likelihood of recurrence may require that a coincident high risk of hardship is also addressed.

36. Risk of hardship is an abstract property of a household that varies across the population and over time according to income, housing characteristics, and energy price. While this risk can be readily understood in a general sense, and its trends described, no quantitative estimates can be offered at either populational or individual level since there is no data available documenting frequency and distribution of cases of actual hardship.

37. While risk of hardship, like all risks, is ineradicable, Government can mitigate its severity via the benefit system, lower income tax, lower taxes and reduced levies on energy costs, reduced taxes on energy efficiency materials and installation costs, and better information to householders.

38. Government can also intervene directly by subsidizing energy efficiency improvements to houses, prioritizing those at greatest risk of hardship.

39. This conceptualization of the problem is of relevance throughout the broader discussion of "fuel poverty", and is particularly important when assessing the impact of energy policies that increase costs to consumers. Rather than attempting to model the number of households that would be classified as "fuel poor" under a particular, and in large part arbitrary, definition *with* and *without poli-*

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[5] Committee on Climate Change, *The Renewable Energy Review* (2011), 136.

[6] The current definition of a household in fuel poverty is one that would need to spend more than 10% of its income to maintain a satisfactory heating regime.

cies, we conclude that it is more informative to use simple descriptions of total costs and where they will fall to provide straightforward insights with regard to general trends, and particular areas which might be exposed to very significant increases in risk.

40. Such discussions of policy impacts on risk of hardship will necessarily be simple in form, and will not generate eye-catching but arguably misleading estimates of the numbers of households driven into fuel poverty. By contrast, they will give approximate indications of the magnitude of the effects through such indicators as estimated bill increases, the identification of types of households that may bear a disproportionate share of these increases, and the likely effect on the proportion of GDP spent on energy.

41. Flowing out of such discussions we can offer further remarks on how government might use what control it has over prices, incomes, and building standards, to reduce risk of hardship, and thus the frequency of cases of actual hardship (which must be detected by investigation and tackled directly).

42. We suggest that a useful but overlooked metric for assessing risk of energy related hardship, and the probable impact of policies, can be found in the proportion of Gross Domestic Product spent on energy. Higher proportions and a rising trend would indicate a probable increase in risk of hardship.

43. There should be no doubt that policy costs are relevant in such a macroscopic context. Taking the Renewable Obligation electricity policy costs described above, we arrive at a total of around £15 billion a year, composed of subsidy, integration, and VAT, which is equivalent to about 1% of current GDP.

44. Since the United Kingdom currently spends around 8.5% of GDP on energy, a further percentage point is a major increase, with far-reaching implications.

45. This can be appreciated from the following chart, which plots expenditure on energy as a percentage of GDP for the United Kingdom and the United States from 1970 to 2007 (US) and 2010 (UK), and also includes the frequency of those judged to be in fuel poverty according to the current definition.

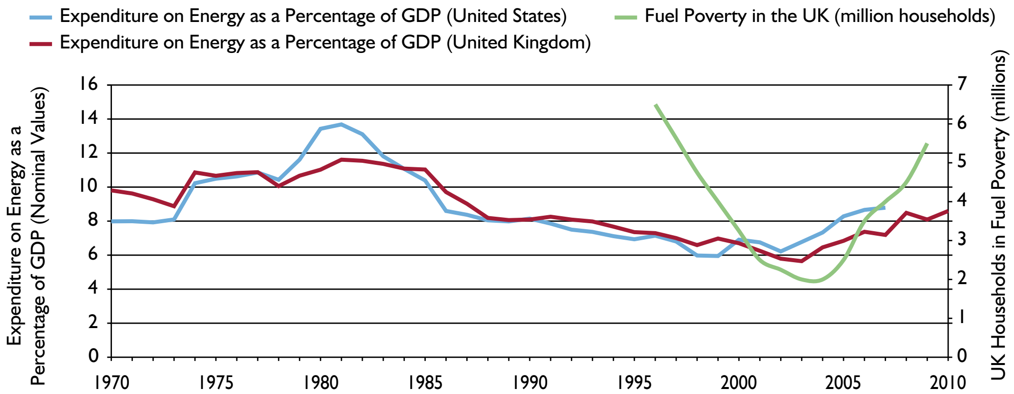

Figure 2: United States and United Kingdom Expenditure on Energy as a percentage of GDP, and millions of households in fuel poverty in the UK according to the standard definition. Source: DECC, US Department of Commerce (Bureau of Economic Analysis), US Census Bureau, Measuringworth.[7] Chart: REF.

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[7] UK energy expenditure figures are drawn from DECC (Digest of United Kingdom Energy Statistics). US GDP obtained from the US Department of Commerce (Bureau of Economic Analysis). US Energy Expenditure is from the US Census Bureau (http://www.census.gov/compendia/statab/cats/energy_utilities.html). UK Nominal GD: MeasuringWorth (http://www.measuringworth.com/aboutus.php).

46. The period during which the energy expenditure to GDP ratio fell coincided with a prolonged period of prosperity in both countries, only to start rising again between 2002 and 2003. We would interpret this as giving a good measure of decreasing and then increasing risk of hardship over the entire population.

47. It is interesting to note that the traditional estimation of numbers of households in fuel poverty numbers produces a curve that is also correlated with energy expenditure to GDP ratio in both countries, an effect that results from the traditional calculation's sensitivity to price. Indeed, the exaggerated nature of that curve arguably confirms suggestions made on other grounds that the traditional calculation is *over*sensitive to price.[8]

48. Importantly, the trends in the United States and the United Kingdom are very similar, indicating that external market prices of energy are a major driver of variation in this measure, a point that underlines the fact that government influence over energy prices to consumers is limited.

49. Examination of the ratio of energy spending to GDP leads us to conclude, as mainstream economics would argue from first principles, that "fuel poverty", or actual hardship and increasing risk of hardship is fundamentally caused by the relation between income and energy price, the latter, as it happens, being largely controlled by factors external to the society concerned.

50. Risk of energy hardship and cases of actual energy hardship result from the relationship between incomes and energy prices, and fluctuations in risk of hardship in the short term are attributable to fluctuations in these variables. That is to say, over shorter timescales they are the *causes* of those matters of concern generally discussed under the title "fuel poverty".

Scandinavian Perspectives

51. Our analysis shows that the Scandinavian countries are well ahead of the UK in improving the thermal efficiency of their housing stock, with significant efforts having been made following the oil shock of 1973. We also show that domestic heating is supported by a diverse and largely indigenous fuel supply, buffering householders against some of the impacts of world fossil fuel price volatility.

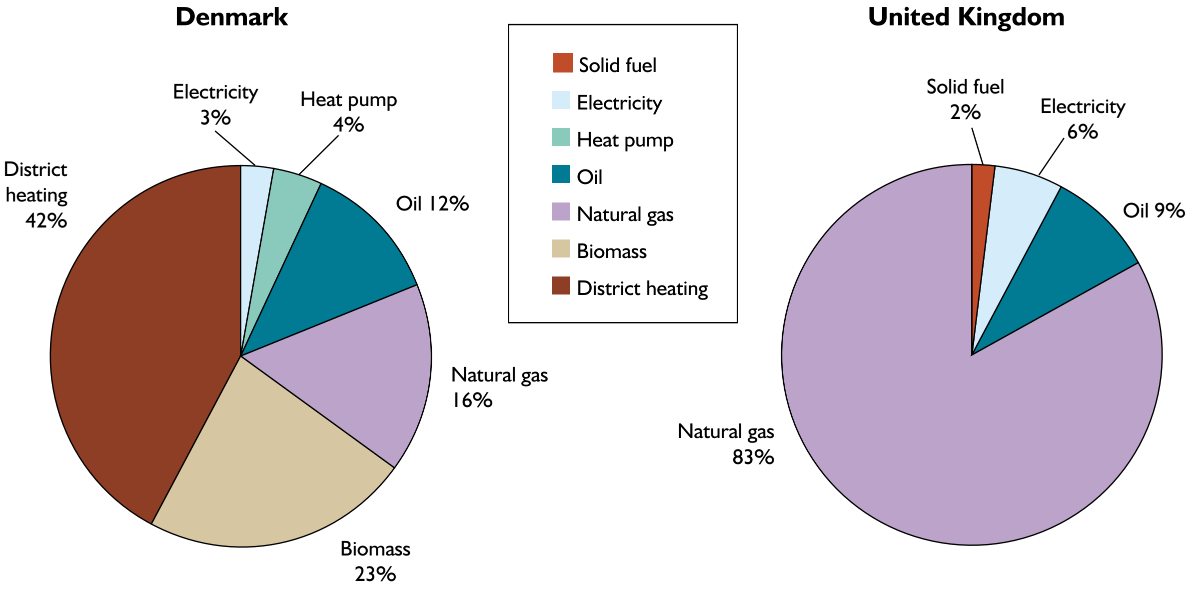

Figure 3: Fuels used for space and water heating in Denmark (left) and the UK (right) in 2010. Source: Danish Energy Agency and DECC.[9] Chart: REF.

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[8] For further comments on this oversensitivity from a different perspective, see John Hills, *Fuel Poverty: The problem and its measurement* (CASE Report: October, 2011), 14, 104–105.

[9] UK data is available from the DECC website – see Overall Data tables at the following URL: http://www.decc.gov.uk/en/content/cms/statistics/publications/ecuk/ecuk.aspx.

52. The diversity of fuel supply for domestic heating in Denmark compared with the UK is illustrated above and reveals the particular importance of district heating in Denmark. Some district heating is provided by biomass and combustible waste but, unlike the UK, all the base load thermal power plants provide district heating and so significantly less of the primary energy consumed in thermal power stations is wasted.

53. District heating is underdeveloped in the UK in spite of evidence that it could feasibly provide up to 14% of the heat demand of UK buildings.[10] There is particular potential where conditions make district heating costs more attractive, including district heating schemes which use waste heat from conveniently sited power stations,[11] schemes which replace expensive electric heating systems, and schemes which supply commercial premises and high rise flats in high heat load areas.

Improving energy efficiency as a moderator of fuel poverty

54. Housing efficiency, often cited as a *cause* of "fuel poverty", is, we suggest, more usefully seen as a moderating factor. That is to say, if fuel prices rise sharply, or incomes fall, then risk of hardship, and the numbers in actual hardship, will rise. The cause of that change is the rise in prices relative to incomes, not a change in the average quality of the housing stock, which is relatively stable over short timescales.

55. However, a household in an energy efficient building will be to a degree buffered against increases in risk of hardship. By contrast, those living in an energy inefficient house might be exposed to a sharp increase in risk of hardship. Difference in housing quality between two such cases is the cause of the difference in relative change in risk of hardship.

56. Bearing this in mind, we can see that energy efficiency measures are exceptionally important to any government attempting to manage the risk of energy hardship, for the following reasons:

57. As noted, government has only limited control over energy costs, which are largely the result of international markets and underlying physical realities. (However, government can avoid adding to the consumer burden through levies and taxes affecting those costs.)

58. Similarly, government has limited control over incomes, which are largely the result of personal circumstances and other incidental matters. However, government can avoid reducing disposable income through tax, and can augment the income of the poorest households through the benefits system (though only by reducing the incomes of selected others who must pay higher taxes).

59. By contrast, government can have profound influence over domestic energy efficiency, which can be controlled through the building regulations, regulations on tenanted properties, information, reduced VAT on energy efficiency materials and installations, and by direct intervention to subsidize the application of energy efficiency measures (though to avoid regressive penalties on poorer consumers such measures would have to be at the taxpayer's expense).

60. The potential for significant savings by improving the energy efficiency of dwellings is well recognized, and a succession of government initiatives has, with some success, attempted to improve the national housing stock.

61. However, the existing policies suffer from conflicting drivers. The EU targets for reducing CO_2 emissions and increasing renewable energy generation are both supported by extremely costly policies that are not compatible with reductions in risk of energy hardship or reductions in the frequency of cases of actual hardship. Alternative policies should be sought as a matter of urgency.

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[10] Pöyry, Faber Maunsell, Aecom.*The Potential and Costs of District Heating Networks* (DECC: April, 2009).

[11] The Pöyry et. al. district heating report estimates costs assuming distances of 15km from the heat source, but notes that Copenhagen has district heating extending 40km across the city.

62. In other areas, where convergence seems plausible, actual delivery proves to be problematic. For example, improving house insulation is clearly worthwhile, but empirical studies reveal that the predicted reductions in energy costs have often not materialized post installation, partly due to problems with the adequacy of the remedial work, but also with flaws in the initial modelling of predicted energy savings. Obtaining data about the value for money, the fitness for purpose of the proposed efficiency measures, and guidance about best practices is improving, but still has some way to go.

63. For theoretical and practical reasons we have reservations about the wisdom of tasking energy supply companies with improving housing efficiencies or reducing fuel poverty. While such companies have data on energy expenditure that is undoubtedly useful for identifying potential hardship, an energy supplier is unlikely to engender the appropriate level of trust, on the one hand, or be in the appropriate business of building refurbishment, on the other. We suggest that energy companies should be left to pursue their core business as efficiently as possible, with more appropriate parties undertaking building refurbishment.

1. Introduction

1.1. This study examines the consumer costs of current energy policies designed to combat climate change. In particular, we examine the impacts on poorer consumers and the increasing risk that they will fall into hardship as a result of paying for these policies through their household bills.

1.2. In Chapter 2 we discuss the acute condition of *actual hardship*, which is caused by an inability to afford sufficient energy to achieve an acceptable standard of living, or the need to forgo other necessities after fuel purchases. We distinguish this from the population-wide *risk* of hardship arising from meeting necessary energy costs. Mitigating this risk, particularly for those with a high probability of suffering hardship, requires long term measures such as consideration of the impact of green taxes and levies, market efficiency, appropriate diversification of energy sources, and improvement of thermal standards for buildings.

1.3. In Chapter 3 we describe the direct, indirect and macro-economic impact of energy levies with particular emphasis on the most costly of these, the Renewables Obligation (RO). The additional direct cost imposed on household electricity bills by the EU 2020 renewable energy target is estimated, as are the indirect costs incurred in integrating the proposed mix of renewable technologies. VAT charged on the climate change levies is also discussed. Finally, the macroeconomic impacts of the climate change policies on income and employment are covered.

1.4. Chapter 4 examines the impacts of the most costly energy policies designed to mitigate climate change, and the relationship between energy costs and GDP is used to look at these trends in relation to risk of hardship.

1.5. Chapter 5 suggests that households using electricity for heating are at particular risk given the disproportionate burden of climate change levies applied to electricity supply.

1.6. Chapter 6 reviews the experience of Scandinavian countries, and Denmark in particular, in addressing similar energy issues. Danish buildings are shown to have a higher relative thermal efficiency than those in the United Kingdom. Furthermore, Denmark has cultivated, at some cost, a diversity of technologies and fuels for space heating, and adopted extensive Combined Heat and Power (CHP), with the result that Danish consumers are less exposed to fossil fuel volatility.

1.7. The potential for improving thermal insulation and energy efficiency of the UK housing stock is discussed in Chapter 7. The results of a series of empirical case studies provide important insights regarding the problems and potential for major refurbishment of UK dwellings to mitigate risk of energy related hardship.

1.8. Chapter 8 presents a survey of the literature relating to a wide range of health problems resulting from inadequately heated homes, and provides a concrete demonstration of the social, physical, and economic realities arising from unaffordable energy. This section provides a grounding point, reminding us of the character of actual hardship and showing why energy and environment policies should be designed to mitigate rather than exacerbate the risk of its occurrence.

2. Hardship and Risk of Hardship

2.1. Current legislation, policy and much campaigning aims to eliminate *fuel poverty*, as described by the current definition.[12] While demonstrating justifiable concern, such a conceptualization of the problem has certain drawbacks, amongst which the most far-reaching is the failure to distinguish between cases of *actual hardship* and general *risk of hardship.*

2.2. By actual hardship we describe households that are unable to maintain a healthy heating regime, or are unable to do so without forgoing other goods and services necessary for health or an acceptable standard of living. In cases of actual hardship the household might be suffering from any of a number of health conditions related to inadequate heating (as described in Chapter 8) or, amongst other problems, be inadequately nourished or clothed.

2.3. Risk of hardship is understood as the probability of a household falling into actual hardship due to a change in circumstances, for example a decline in income or a rise in energy prices, and applies to all households, though the probability will exhibit a very wide range across the population, some being at very high risk and some at very low risk.

2.4. Actual hardship is an acute problem requiring immediate attention from the medical and social services, though reducing the likelihood of its recurrence may entail that an underlying high risk of hardship is also addressed.

2.5. Due to lack of data relating to the frequency of cases of actual hardship we cannot currently quantify the risk of its occurrence, but this need not prevent us from using the abstract conceptualization to refine our analysis of fuel poverty, which at present tends to be understood as a compound of actuality and risk. This seems unfortunate since, as noted above, policies to address these two problems must vary in character.

2.6. Notably, while it is in principle possible to reduce cases of actual hardship to zero, which is highly desirable, risk of hardship, like all risks, is in principle ineradicable, though it can be managed and reduced to acceptable levels.

2.7. A strategy that recognizes the distinction will, firstly, aim to identify and assist those who are in actual hardship as the result of energy costs that are so high, and building characteristics that are so poor, as to either require those individuals to forgo the purchase of energy services adequate to their needs, or to forgo other necessary goods or services. This is an acute problem requiring prompt remedial action.

2.8. Secondly, the strategy will aim to reduce the population-wide risk of such energy-related hardship, which is the focus of this study. This is a chronic problem, arising from the interaction of fluctuations of both income and energy prices against a background of building quality. Moderating such risk requires long-term strategies relating to each of these three variables.

2.9. Implicit in this framing is the understanding that while policies aimed at addressing actual hardship may have some impact on future risks, they are necessarily focused on a subset of the population and on the short term. Similarly, policies designed to bring about a reduction in the population-wide risk profile may do little in any relevant timeframe to assist with existing cases of actual hardship. This limitation, however, does not mean such policies are less important, only that they are preventative rather than curative in character.

2.10. A re-orientation of this kind is particularly necessary for those considering, as this study does, the impact of energy policies, which have an indirect relationship with cases of actual hardship. That is

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[12] The current definition of a household in fuel poverty is one that would need to spend more than 10% of its income to maintain a satisfactory heating regime.

to say, policies are affect population-wide *risk* of hardship, which then generates cases of actual hardship in combination with variable circumstances, a particularly hard winter for example. A trend indicator that gave the analyst some conception of the sign of the trend and also the scale of risk variation over time would be of real value. However, for this purpose the currently standard fuel poverty definition seems to be poorly designed.

2.11. In this relation, we accept the interim Hills Review's report's suggestion that the current definition of fuel poverty is generally problematic, and that, as the authors remark: "to support action we need good measurement […] Bad measurement can hinder", a very helpful general observation.[13]

2.12. Some of the faults with the current measure, as described in the Hills Review also apply to its effectiveness as a means of assessing policy impacts. Namely, the current definition relies an arbitrary procedure that has insufficient purchase on the real world to deliver practical insight. Specifically, the definition employs a model of the English housing stock to estimate spending that would be required to realize a specified heating regime. This required spending is then expressed as a ratio of household income, and a particular threshold is then specified as being a cut-off for those in or out of fuel poverty. The interim Hills Review deals with many of the problems arising from this definition in a detailed and constructive manner, and we see no need to replicate this work, with which we are in broad agreement.

2.13. However, it is worth pausing to consider why the definition has survived for so long and why there is still reluctance to consider its revision.

2.14. Part of the confusion of approaches is due to the analogical inspiration behind the term *fuel poverty*. This term is employed in a special sense in the United Kingdom,[14] as described above, but draws emotional loading from the senses of "energy poverty" in international development economics, where the term is understood as "the lack of access to clean modern fuels".[15] In most cases this term refers to the lack of electricity, with about 1.5 billion people globally, 25% of the world population, having no access to this energy carrier.[16] This latter sense is non-arbitrary, easily determined, and the disadvantages readily recognized. The absence of electric light, for example, has educational and economic disadvantages, and the use of biomass and coal for cooking and heating in simple open combustion leads to domestic air quality problems and significant damage to health ("hut lung").

2.15. This type of energy poverty is unquestionable, and membership of the category can be determined by intersubjective criteria. By contrast the UK definition, that more than 10% of household income would need to be spent to maintain a specified heating regime, is arbitrary (why not 9%, or 11%, of income?), and parochial in that it associates this level of spending with hardship relative to national norms, whereas by international standards such households might be regarded as being relatively fortunate.

2.16. The arbitrary nature of the definition has attracted significant criticism, with Healy (2004, 35) referring to the "non-existent scientific rationale" for the 10% line, and Waddhams Price et al. (2007, 18) indicating that many of those categorized as fuel poor by this rule do not regard themselves as so. (In our view it is likely that such people are, to use the terms suggested in the present study, at significant risk of hardship, but not actually experiencing hardship.)

2.17. However, the definition has survived, and it seems likely that part of the explanation for this is that the analogy with "fuel poverty" in the international sense gives the conventional UK policy definition a political and emotive power that compensates for its analytical deficiencies. This rhetorical advantage has ensured that the term has remained in use and seems to many an indispensable part

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[13] John Hills, *Fuel Poverty: The problem and its measurement* (CASE Report: October, 2011), 3.

[14] National Audit Office, *The Warm Front Scheme* (2009), 35.

[15] Editorial, *Oxford Energy Forum*, 81 (May 2010), 1.

[16] Robert Bacon, "Energy Poverty", *Oxford Energy Forum,* 81 (May 2010), 3.

of the discourse. Indeed, there is a widespread fear in the fuel poverty literature that any re-examination of the definition and the targets relating to fuel poverty may weaken the resolve to address the fundamental issues involved.

2.18. This concern is understandable, but, in our view, mistaken. The goal of any analysis of this field must be firstly *to assist households that are experiencing actual hardship*, and secondly to reduce risk so that cases of actual hardship are less frequent. By conflating these problems the current tools fail to conceive the problem in a way that facilitates focused and productive action. Indeed, in some ways the current definition is needlessly dispiriting with regard to policy measures, for example building efficiency improvements that are extremely valuable as risk mitigators but seem powerless to "eradicate fuel poverty".

2.19. Considerations of this kind are particularly important when analyzing the impact of energy policies since we are concerned not so much with cases of acute actual hardship, but risk, a risk that must be understood as a graduated phenomenon affecting all households to a greater or lesser degree, and arising from the interaction of incomes, on the one hand, and energy prices on the other. When incomes are constrained, householders may i) decide not to purchase sufficient energy resources to heat a home to a level required for health or comfort, resulting in probable physical hardship, or ii) proceed with the purchase and reduce other expenditures, or iii) incur debts. These decisions imply risk of hardship, physical (medical), or financial.

2.20. We judge that current policies are already increasing risk of hardship, and will thus increase the frequency of cases of actual hardship. The purpose of this study is to focus that concern to best effect by suggesting several things that government should do, and several things that it should cease to do.

3. The Impact Character of Energy Policy

3.1. Direct, Indirect, and Macroeconomic Impacts

3.1.1. Levies increasing energy costs to consumers to support climate change policies have impacts of various kinds bearing on the risk of hardship and energy affordability. Namely, *direct impacts* caused by the levies themselves, *indirect impacts* caused by increased system costs resulting from the adoption of certain renewable technologies, principally wind, and macroeconomic impacts, for example income, employment, and cost of living effects caused by fiscal burdens on and rising energy prices for the industrial and commercial sector.

3.1.2. By and large those examining fuel poverty have concerned themselves with direct impacts only, but the evidence presented below suggests that indirect and macroeconomic effects are significant and may have a major determining effect on population-wide risk of hardship and the consequent frequency of cases of actual hardship.

3.1.3. Direct impacts are relatively straightforward to quantify, since the subsidy costs of the various programmes are reasonably well understood, though still under-appreciated outside the energy sector.

3.1.4. By contrast, the indirect impacts of policies on overall energy system costs are problematic, and insufficiently studied. These extra costs vary in character from technology to technology, with the most significant arising in the electricity sector as a result of the introduction of high levels of wind power, which is uncontrollably variable. Accommodating these disadvantages requires grid expansion and reinforcement, an increased level of rapid response plant to handle errors in the wind forecast, and the operation at low load factor of a conventional generation fleet equivalent to peak load (plus a margin) in order to preserve security of supply.

3.1.5. Macroeconomic impacts of policies have been little studied in the United Kingdom, and are not widely appreciated as a potential accentuating factor in risk of energy hardship. However, levies on energy bills, such as that used to support renewable electricity generators, and any fiscal burden, such as that providing funds for the Renewable Heat Incentive, will have a suppressive effect on economic activity in those sectors on which the levies and taxes fall.

3.1.6. Put aphoristically, while the gross impact of subsidies may be positive, in other words they will create jobs in the supported sectors, the net economic impact may be negative due to lost employment or reduced wages in other sectors.

3.1.7. We will deal with each of these impact areas in turn, starting with Direct impacts.

3.2. Direct Impacts

3.2.1. Direct impacts on electricity bills occur when the costs of a policy, for example the Renewables Obligation, are passed through to consumers. In this particular case, the scale of these pass-through costs can be estimated by reference to the quantities of renewable electricity generated in a given period, data which is available from Ofgem's ROC Register,[17] and to ROC auction prices.[18]

3.2.2. In previously published work using the then current estimates of target levels and likely technologies the Renewable Energy Foundation has estimated the actual cost of the renewables programme to the consumer at around £5.6 billion in the period 2002 to 2010, with a likely on-

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[17] See: https://www.renewablesandchp.ofgem.gov.uk/. The Renewable Energy Foundation also processes this data and presents it in a more readily useful form: http://www.ref.org.uk/energy-data.

[18] See: http://www.e-roc.co.uk/trackrecord.htm.

cost of a further £35 billion up to 2020, at which point the annual subsidy cost would be around £6 billion.[19]

3.2.3. This latter quantity is consistent with similar numbers found in the Climate Change Committee's *Renewable Energy Review* of May 2011,[20] which estimates that renewables policies would put 2p/kWh, or £6.5bn, on the national electricity bill in 2020, which is an increase in the wholesale price of between 14 and 28 percent on the Committee's assumptions regarding wholesale prices at that point.

3.2.4. The accuracy of the empirical part of our earlier calculations was confirmed in a recent Parliamentary answer, when Lord Marland, Parliamentary Under-Secretary of State at the Department of Energy and Climate Change, revealed that the department estimated the cost of the Renewables Obligation between April 2002 and March 2011 to be approximately £7.3bn.[21]

3.2.5. However, Government has made no estimate of the current and future impacts of this and other relevant policies on fuel poverty in the conventional definition, as can be seen from the following answers given by Lord Marland to Lord Vinson:

> **Lord Vinson:** To ask Her Majesty's Government how many households are currently in fuel poverty, according to the standard definition; and what proportion of that total they estimate is the result of extra costs on the consumer due to environmental policies.
>
> **Lord Marland:** […] There has been no estimate made of the total cost of environmental policies on fuel poverty.
>
> **Lord Vinson**: To ask Her Majesty's Government how many households they expect to be in fuel poverty in 2020; and what proportion of that total they expect to be the result of costs on the consumer due to environmental policies applied at that time.
>
> **Lord Marland:** […] There are no estimates of the effect of all environmental policies in 2020.[22]

3.2.6. This is an outstanding omission, and we suggest that Government should undertake such studies to facilitate an improvement in understanding of the likely future impact of current policies, though such impact assessments should make use of the improved procedures being developed by the Hills Review, and of more general risk assessment indicators such as the ratio of energy spending to GDP (discussed elsewhere in this study).

3.2.7. We have updated our estimates of future subsidies to renewables in the light of more recent Government statements, particularly the 2011 UK Renewable Energy Road Map.[23] In making these revisions we have assumed that the reductions in support levels for onshore and offshore wind proposed by DECC for the period 2013 to 2017 are carried through.[24] We have further assumed, which we believe is reasonable, that the Electricity Market Reform package, in whatever form it eventually manifests itself, will, because of the need to meet the EU 2020 targets, be unable to significantly reduce subsidy costs to the consumer, and while we note Government's

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[19] See REF, "The Probable Cost of UK Renewable Electricity Subsidies to 2002-2030" (http://www.ref.org.uk/publications/238-the-probable-cost-of-uk-renewable-electricity-subsidies-2002-2030). See also, John Constable, *The Green Mirage* (Civitas: London, 2011), 103-109.

[20] http://www.theccc.org.uk/reports/renewable-energy-review

[21] *Hansard*, 25 Oct 2011: Columns WA126-WA127. http://www.publications.parliament.uk/pa/ld201011/ldhansrd/text/111025w0001.htm

[22] Lord Vinson, Parliamentary questions 12384 and 12385, 21.10.11, Hansard, WA104.

[23] UK Renewable Energy Roadmap, 2011, DECC http://www.decc.gov.uk/assets/decc/11/meeting-energy-demand/renewable-energy/2167-uk-renewable-energy-roadmap.pdf

[24] http://www.decc.gov.uk/en/content/cms/consultations/cons_ro_review/cons_ro_review.aspx

aspiration to drive down the costs of offshore wind[25] we do not regard this as probable in the timescale proposed.

3.2.8. The following chart plots the likely pattern of annual subsidies to renewable electricity from the present day to 2030:

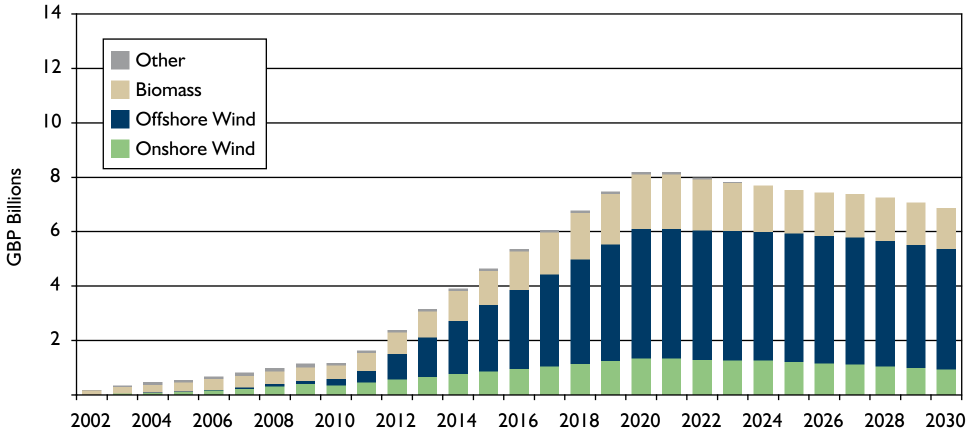

Figure 4: Projected Growth in Renewable Electricity Subsidy Costs to 2030.
Source: REF Calculations.

3.2.9. Annual subsides in 2020 exceed £8 billion, and the total subsidy taken from 2002 up to that year is around £55 billion, with approximately one third of that figure being charged on domestic bills. If we assume that no attempt is made to meet higher targets than those currently in place, and that, while no subsidy is paid to any new renewable generators built post 2020, the 20 year obligation to support pre-2020 generators is honoured, the total subsidy drawn from consumers in the period 2002 to 2030 will be in the region of £130 billion.

3.2.10. In passing we observe that there are good theoretical grounds, pointed out in 2008 by Dieter Helm in a comment on fuel poverty, that levies which have direct impacts on the competitive section of a market have detrimental distorting effects on the overall efficiency of that market that go beyond the levy itself, thus exposing the consumer to higher costs than would otherwise be the case.[26]

3.2.11. This is relevant both to policies that intend to raise funds to subsidize renewables, or any other chosen technology, and to attempts to cross-subsidize low income consumers who face high levels of risk of hardship. Helm recommended that government should consider placing levies on the monopoly component of the electricity and gas markets, namely the distribution section (i.e. the transmission and distribution grid for electricity and the gas pipeline network), rather than the supply or generation sector:

> The supply route distorts, driving a wedge between price and costs, and it is inevitably complex. The distribution route is superior, and it naturally builds on the system nature of the electricity and gas networks. If the government is serious about fuel poverty, and about energy efficiency and decentralized generation, then it is time to recognize that trying to turn suppliers into social and environmental providers—into businesses that cross-subsidize and try to reduce their sales—has not only failed so far, but has failed for quite fundamental reasons. Given the radical natural of both the fuel poverty and environmental agendas, it should turn to the

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[25] http://www.decc.gov.uk/en/content/cms/news/pn11_81/pn11_81.aspx

[26] Dieter Helm, "How to Tackle Fuel Poverty" (2008). See: http://www.dieterhelm.co.uk/sites/default/files/Fuel_Poverty_Jul_08.pdf.

> distribution businesses as the natural agents for policy delivery. They are systems, they have regulated asset bases, and they are monopolies regulated in the public interest.[27]

3.2.12. It is regrettable that this profound and constructive observation has gained so little traction in government, either when considering fuel poverty alleviation mechanisms or renewable support policies.

3.3. Indirect Impacts: System Costs

3.3.1. Attempts to go beyond assessment of the costs of subsidies are few and far between. Even the most prominent, such as *The Costs and Impacts of Intermittency* (2006) from the United Kingdom Energy Research Centre (UKERC),[28] failed to reassure analysts that the costs would be low. Subsequent improvements in the understanding of the characteristics of the intermittency of wind, particularly that resulting from Oswald's seminal paper in 2008,[29] as well as empirical evidence from Denmark, Germany, and the United Kingdom itself, have confirmed suspicions that earlier studies have tended to take too narrow and optimistic a view of the cost factors. Recent studies tend to highlight concerns about the cost of integration, and discussion of such matters is now a rapidly growing field.[30]

3.3.2. However, although costs are now known to be higher than hitherto assumed, tolerably precise attempts to estimate the consumer burden of high levels of intermittent generation are rare. In this study we draw on new work by Colin Gibson (formerly Power Networks Director at National Grid) and published as a working paper by the Institution of Engineers and Shipbuilders in Scotland (IESIS), *A Probabilistic Approach to Levelised Cost Calculations for Various Types of Electricity Generation* (2011).[31]

3.3.3. Gibson's work builds on cost estimates conducted for the Department of Energy and Climate Change (DECC) by Mott MacDonald, ARUP, and PB Power,[32] but adds many extensions to their work.

3.3.4. His approach can be summarized thus:

> For these studies, the levelised cost […] of a type of generation is taken as all the costs as seen by the customer discounted with regard to time, divided by the energy output also discounted with regard to time. The discount rate used is the average weighted cost of capital. The costs include, for intermittent generation, all the costs of delivering to the customer the same "product' in respect of Security of Supply and frequency control of non-intermittent generators.

3.3.5. It is not our intention here to enter into a detailed explication and commentary on the study, but rather to summarize its findings as an indication of the direction in which informed engineering analysis is now taking in estimating the cost of intermittency.

3.3.6. The following chart, from Gibson's own spreadsheet, provides the S curves describing the probabilistic analysis of costs for each of the technologies considered:

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[27] "How to Tackle Fuel Poverty", 5.

[28] http://www.ukerc.ac.uk/support/Intermittency

[29] Jim Oswald et al. "Can British Weather Provide Reliable Electricity", *Energy Policy* 36 (2008), 3202–3215.

[30] See for example, Pöyry's study, *The challenges of intermittency in North West European power markets: The impacts when wind and solar deployment reach their target levels* (2011) (http://www.poyry.com/media/media_2.html?Id=1301471113.html). For further discussion see: http://www.ref.org.uk/publications/227-new-study-confirms-ref-intermittency-studies

[31] Colin Gibson, *A Probabilistic Approach to Levelised Cost Calculations for Various Types of Electricity Generation* (2011). The paper and the accompanying spreadsheet is freely available from http://www.iesisenergy.org/lcost/. For comments by one of Europe's leading power engineers, Paul-Frederik Bach, see http://pfbach.dk/.

[32] http://www.decc.gov.uk/en/content/cms/about/ec_social_res/analytic_projs/gen_costs/gen_costs.aspx

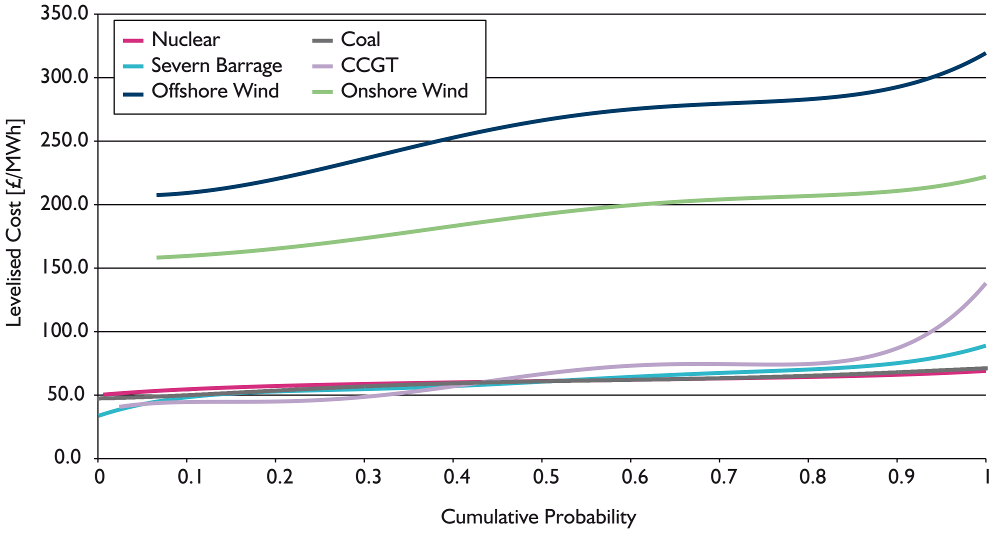

Figure 5: Summary of Levelised Costs.
Source: Gibson (2011).[33] Chart redrawn by REF.

3.3.7. It will be immediately appreciated that the median costs (those lying on the 0.5 probability mark) for nuclear, the Severn Barrage, coal, and Combined Cycle Gas Turbines are in the range of £60–£70/MWh, whereas the results for offshore and onshore wind are £265/MWh and £190/MWh respectively.

3.3.8. Gibson's assessment of the intermittency costs of onshore and offshore wind can be rendered in simple form in the following table, where Extra System Operation costs refer to the costs of fast response plant to address the intermittency of wind in the operational timescale (i.e. in the very short term, or minutes and hours), while Planning Reserve refers to the need to maintain an underutilized conventional fleet equivalent to peak load (plus a margin) to cover periods when output from the wind fleet falls to extremely low levels (Gibson assumes a level of 8% of installed wind capacity). Required Transmission describes the cost of grid needed to transport energy from wind sites to consumers.[34]

Table 1: Additional System Costs for Onshore and Offshore Wind (£/MWh of wind power generated).
Source: Gibson (2011).[35]

Technology	*Extra System Operation Costs (£/MWh)*	*Capital Charges for extra planning reserve (£/MWh)*	*Total Capital Charges for Required Transmission (£/MWh)*	*Total (£/MWh)*
Onshore Wind	16	24	20	60
Offshore Wind	16	28	23	67

3.3.9. To put these estimates of additional system costs into perspective it should be recalled that the current subsidy income, discussed above, is roughly £50/MWh for onshore wind and £100/MWh for offshore wind.

3.3.10. Taking these estimates and the subsidy required to meet the 2020 targets, as described above, we can calculate, very roughly, the annual cost of the renewable electricity sector to the consumer in 2020. For this purpose we assume that 13 GW of onshore and 18 GW of offshore

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[33] http://www.iesisenergy.org/lcost/

[34] See paragraphs 3.1.6 to 3.1.8 of *A Probabilistic Approach to Levelised Cost Calculations for Various Types of Electricity Generation.*

[35] http://www.iesisenergy.org/lcost/

wind are built by 2020, which are the central range assumptions given in DECC's UK *Renewable Energy Roadmap*,[36] and that, as Gibson assumes, the onshore and offshore wind-fleet achieve load factors of 25% and 32% respectively.

3.3.11. On this view the total annual cost in 2020 will be over £13 billion, consisting of £8.2 billion of subsidy, and about £5 billion of additional system costs. The growth in this cost is plotted in the following chart:

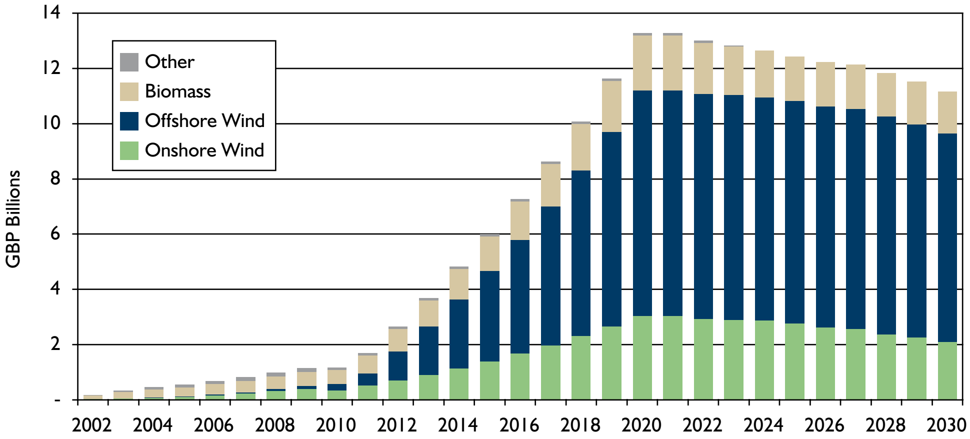

Figure 6: Projected Growth in Total Cost of Renewable Electricity Programme (Subsidy + Ancillary Costs).
Source: REF Calculations, Gibson 2011.

3.3.12. There must some doubt as to whether the integration costs suggested in Gibson's work would apply at the lower installed capacities, for instance in 2015, so a linear gradient from zero in 2012 to the full quantum in 2020 has been used, but the uncertainty in this procedure is acknowledged.

3.3.13. Nevertheless, as an indicative rather than a predictive exercise Gibson's analysis provides valuable insight as to the order of magnitude of the total programme cost in 2020 and beyond.

3.3.14. As noted above, approximately one third of this cost would find its way through to bills for domestic consumers, and two-thirds would be paid by industrial and commercial consumers, with a large part of this being eventually being passed through to UK consumers in the prices of goods and services.

3.3.15. This would represent an increase on current annual domestic electricity costs of approximately £130, or 30%, over current costs for those households with a moderate electricity consumption of 3,300 kWh per annum.[37]

3.3.16. However, for those who use electric heating we estimate the increase would be approximately £320 per annum on their space heating costs alone, before retail margins and VAT, a point that underlines the inconsistency between the climate change and fuel poverty agendas.

3.3.17. On Gibson's estimates there would be a significant increase in the cost of living across the entire population, with those using electric heating being exposed to high levels of risk of hardship. Actual hardship would be common.

3.3.18. Even those able to use gas for heating may be exposed to a higher overall risk of hardship due to rising electricity bills and increased cost of living.

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[36] UK Renewable Energy Roadmap, 2011, DECC http://www.decc.gov.uk/assets/decc/11/meeting-energy-demand/renewable-energy/2167-uk-renewable-energy-roadmap.pdf

[37] Current domestic electricity cost is assumed to be £446 per annum for an average electricity consumption of 3,300 kWh per annum and is taken from Table 2.2.3 in DECC's Quarterly Energy Prices September 2011. See http://www.decc.gov.uk/assets/decc/11/stats/publications/qep/2867-qep-sep11.pdf

3.3.19. In view of the possibility of such costs it would be prudent for Government to reconsider commitment to the pace of development outlined in the EU Renewables Directive.

3.3.20. Apart from the suspension of targets, no other response offers complete mitigation, but it is obvious that those using electric heating would be at severe risk of hardship and would have to be the focus of remedial measures. One possible response would be to encourage such households to switch to gas where possible, but this would be inconsistent with the Government's intention to partially decarbonize heating through renewable electricity.

3.3.21. Alternatively, special measures might be introduced to encourage electrically heated households to switch to subsidized renewable heat, including biomass, and ground-source and air-source heat pumps, perhaps using the Green Deal as a means of financing the measure.

3.3.22. However, very careful monitoring of these installations would be necessary to detect failure or under-performance exposing households to undue costs.

3.4. Indirect Impacts: VAT

3.4.1. Furthermore, levies on energy, and additional system costs, are applied before Value Added Tax (VAT) is calculated, with the consequence that when the electricity is sold on to customers, VAT is applied to the levies, either at 5% for domestic and certain discounted customers, such as charities, and 20% for all other customers.

3.4.2. Domestic consumers will feel this impact directly, and immediately, but VAT registered businesses may be able to reclaim part of this tax. However, the costs of the levies themselves will remain and be passed through to form part of the product or service price that will be liable to VAT if purchased and consumed within the UK or the EU. Thus the VAT impact of levies on sales of electricity to commercial purchasers is delayed and falls on the final consumer of goods and services, not necessarily on the electricity consumer, and will be a contributory element to rises in cost of living due to energy policies. Due to the complexity of VAT it is difficult to form a reasoned estimate of the scale and location of such VAT impacts, but the general order of magnitude of the VAT uplift itself can be estimated from the cost of the levy concerned.

3.4.3. For example, the Renewables Obligation in 2010 cost just under £1.2bn, implying a VAT uplift of up to £175m. The following table illustrates the effect.

Table 2: Renewables Obligation Costs and VAT in 2010.
Source: REF Calculations from DECC and Ofgem Data.

The Renewables Obligation: Approximate Costs and VAT in 2010	*Cost (£ Millions)*
Domestic share of RO cost	424
Industrial & Commercial share of RO Cost	749
RO in 2010: Total Cost	1,173
Domestic VAT	21
Industrial & Commercial VAT	150
Total VAT	171
RO cost in 2010 plus VAT	1,344

3.4.4. The total cost of the Renewables Obligation has been calculated from Ofgem Renewables Obligation Certificate (ROC) records, and on the assumption of a ROC price of £50/MWh. The domestic and industrial and commercial shares of consumption have been derived from the Department of Energy and Climate Change's *Digest of United Kingdom Energy Statistics*, Table 5.2.

3.4.5. Since it is has proved impossible for us to offer any reasoned estimate of the proportion of industrial and commercial consumers that pay VAT at the reduced rate (5%) we have not made any effort to allow for this. The total VAT figure is, therefore, probably somewhat too high, and should be regarded as approximate only.

3.4.6. It can be observed that this point applies to all the levies upon bills, and due to a parliamentary answer given by Lord Marland in response to a question from Lord Vinson, we are able to sum Government estimates for the various policies:

Table 3: Levy-funded Energy Policy Costs.
Source: Hansard.[38]

Policy	*Period considered*	*Est cost £m (real 2010–2011 prices)*
Energy Efficiency Commitment (EEC) I	04.02–03.05	500
Energy Efficiency Commitment (EEC) II	04.05–03.08	1,000
Carbon Emissions Reduction Target (CERT)	04.08–03.11	3,300
Carbon Emissions Reduction Target (CERT) Extension	04.11–10.11	600
Community Energy Saving Programme (CESP)	09.09–10.11	200
Feed in Tariffs (FiTs)	04.10–07.11	20
Renewables Obligation (RO)	04.04–03.11	7,310
Total cost of levies	2002–2011	12,930

3.4.7. While we do not have information relating to the distribution over types of fuel and types of purchaser for all these costs, we can estimate the VAT uplift by assuming a roughly similar distribution for that found with electricity, at ca. £1.9bn between 2002 and 2011, with about £230m of that being paid by domestic consumers. These should be regarded as an order of magnitude assessments only.

3.4.8. With regard to those policies exacting levies on electricity our estimate can be more confident. Lord Marland's answer tells us that that from its initiation in April 2002 up until March 2011 the Renewables Obligation has cost consumers £7.31bn.[39] Using the same proportions as described above we can calculate that the Treasury has derived a VAT uplift of approximately £950 million from this subsidy.

3.4.9. Similarly, we can produce an estimate of the VAT likely to be charged on the Renewables Obligation in 2020:

Table 4: The costs of the Renewables Obligation in 2020

The RO in 2020	*RO Subsidy Cost (£bn)*	*VAT (£bn)*	*Total inc. VAT (£bn)*
Domestic share of RO Subsidy	3.0	0.1	3.1
Industrial & Commercial share of RO Subsidy	5.2	1.1	6.3
RO Total Subsidy	8.2	1.2	9.4

3.4.10. Thus, we can see that there would be a VAT uplift of around £1.2bn, or 14 per cent of the total subsidy cost to the consumer in 2020. Of particular interest in the context of this study, we find that at the domestic level the RO would be costing approximately £3.1 billion, or £100 per

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[38] *Hansard*, 25 Oct 2011: Columns WA126-WA127. http://www.publications.parliament.uk/pa/ld201011/ldhansrd/text/111025w0001.htm

[39] *Hansard*, 25 Oct 2011: Columns WA126-WA127.

household, if averaged over 29 million households (DEFRA's projection for that year), of which about £5 would be due to VAT alone.

3.4.11. This is approximately consistent with DECC's own estimates of the RO cost, as described in *Estimated impacts of energy and climate change policies on energy prices and bills* (July 2010), where in Table E2 we find the cost of the existing RO and the extended RO as accounting for £94 of an average domestic electricity bill in 2020 of £512.[40]

3.4.12. Furthermore, assuming that our calculations of total cost (i.e. subsidy plus integration costs) are broadly correct, the total policy cost to consumers will be in the region of £13 billion a year, implying a total VAT uplift of £2 billion a year, of which about £240 million would be charged on domestic consumer bills.

3.4.13. The remainder of that sum, about £1.7 billion, would be charged on industrial use, with some part of that sum ultimately passed through to end consumers of goods and services. Even though the VAT uplift on the levy component of the cost of goods and services is very difficult to locate and estimate, it is obvious that there could be a significant effect on the cost of living.

3.4.14. The potential scale of the VAT uplift is far from negligible in the context of efforts to reduce risk of hardship and the numbers of cases of actual hardship arising from energy costs, but in any case we believe that such an uplift is undesirable as a matter of fiscal principle. While there are precedents for the application of taxes to taxes in the UK, and indeed in Sweden VAT of 25% is applied to the sum of network costs, electricity costs, and the energy tax,[41] the fundamental case for such actions should be re-examined.

3.4.15. Our view is that there is no justification for the state to augment its tax income silently and in distributed fashion throughout the economy by increasing energy costs via legislation. Such a route evades parliamentary scrutiny, lacks general transparency, and hence is likely to arouse distrust.

3.4.16. Given these concerns, we suggest that Government should introduce special measures to prevent VAT being applied to the levy component of energy prices in any market. This should be relatively straightforward for domestic bills, where there is a very strong argument for much clearer statements of the component charges that go to make up a bill.

3.4.17. However, we appreciate that there are difficulties in disaggregating the energy levy component in the cost of a good or a service, and that requiring businesses to make such calculations would in all probability be an unreasonable imposition. Nevertheless, the problem remains, and the difficulty in resolving it constitutes, in our view, a strong argument against government spending that is financed through mandated levies.

3.4.18. While it might be argued that Government should return the monies already taken, precisely targeted refunds are doubtless impractical. However, Government could consider a temporary VAT rebate on electricity to return these funds to the economy.

3.4.19. Secondly, there is the question of the impact of this VAT on the risk of hardship in relation to household heating. For the approximately two million households relying on electricity for their main heating source, and for those who use it as supplementary heating in emergencies, we suggest that the VAT charged on the Renewables Obligation has already been a significant factor in causing an increase in risk of hardship, and is very likely to be so in the future.

3.4.20. Overall, VAT on levies is already part of the impact of policies on domestic bills, and it is certain that this impact will increase. Since the application of tax at this point has no positive

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[40] DECC, *Estimated impacts of energy and climate change policies on energy prices and bills* (July 2010: URN 10D/719).

[41] Jurke Pyrko and Sarah Darby, "Conditions of behavioural changes towards efficient energy use: a comparative study between Sweden and the United Kingdom", *ECEEE* (Summer 2009), 1795.

bearing on the success or otherwise of the energy policies themselves, being a needless extra cost, Government should review the charging of VAT on its energy levies.

3.5. Macroeconomic Impacts

3.5.1. Fuel poverty analysts and campaigners have, generally, been concerned with those impacts of energy policies that increase consumer bills. However, there are good reasons for thinking that such policies may have important and depressing effects on income and employment, since they increase the costs of energy and reduce economic activity in consuming sectors.

3.5.2. Whether this depressive effect is compensated for by growth in the subsidized energy sector is debatable. That is to say, while the gross effect of state mandates and subsidies in the energy sector may be positive, it does not necessarily follow that the net effect in either employment or GDP is positive; the cost of creating employment in one sector may destroy more jobs in the other. One of the present authors, John Constable, has been prominent in drawing attention to this concern in the United Kingdom, and the following section summarizes material put forward in his book, *The Green Mirage: Why a low carbon economy may be further off than we think*.[42]

3.5.3. Since the European Union's policies for renewable energy and emissions reduction lie behind and direct the UK Government's own policies, consideration of macroeconomic impact can and should start at that level. Fortunately, the EU has itself conducted a comprehensive analysis of these impacts, namely *EmployRES: The Impact of Renewable Energy Policy on Economic Growth and Employment in the European Union* (27 April 2009), which is a study commissioned and funded by the European Commission's Directorate General of Energy and Transport (DG TREN). The authors were drawn from six collaborating consultancies from Germany, The Netherlands, France, Austria, Switzerland and Lithuania.[43] The result is a substantial document (the summary alone is 27 pages long) and forms the EU's major technical discussion of its green economy agenda.

3.5.4. However, the fundamental findings are by no means as reassuring as might be expected, and *EmployRES* deserves to be much better known and more widely discussed, particularly in the UK, for which the study predicts a policy-induced brake on economic growth, and net employment losses, even in some of the most optimistic scenarios.

3.5.5. Furthermore, the study finds that at best the EU's overall economic gains from the renewables policies are, to use *EmployRES's* own term, "slight', and in any case almost entirely dependent on the EU maintaining a more than 50% share of the global green technology market, and thus maintaining high levels of exports, which seems optimistic, particularly in the light of the European debt crisis.

3.5.6. We can turn to the first paragraph of the *EmployRES* summary:

> Improving current policies so that the target of 20% RES in final energy consumption in 2020 can be achieved will provide a net effect of about 410,000 additional jobs and 0.24% additional gross domestic product (GDP).[44]

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[42] John Constable, *The Green Mirage: Why a low carbon economy may be further off than we think* (Civitas: London, 2011).

[43] Fraunhofer ISI, Ecofys, Energy Economics Group (EEG) Austria, Rütter + Parter Socioeconomic Research + Consulting (Switzerland), Société Europèene d'Économie (SEURECO) France, Inga Konstantinaviciute (LEI) Lithuania, *EmployRES: The Impact of Renewable Energy Policy on Economic Growth and Employment in the European Union* (27 April 2009). Study for DG TREN, Contract TREN/D1/474//2006. Summary and main text downloadable from: http://ec.europa.eu/energy/renewables/studies/renewables_en.htm.

[44] Summary, *EmployRES*, p. 4.

3.5.7. This compares with a gross effect of 3 million new jobs in the renewables sector, indicating that over 2 million jobs in other industries are destroyed as a result of the displacement and energy price increasing effects of the renewables policies. This is a relatively small gain in relation to the total size of the European Union, and in regard to the scale of the proposed transition, which entails a reallocation of resources unprecedented in peacetime.

3.5.8. The authors of *EmployRES* use an "input-output" model (MULTIREG) to estimate the impacts of renewable energy sector development, itself predicted by another model (GREEN-X), on other economic sectors. These macroeconomic impacts are examined via two independent models, NEMESIS and ASTRA, and the results compared. The authors describe this as "the first study to assess the economic effects of supporting RES [renewable energy sources] in this detail, looking not only at jobs in the RES sector itself, but taking into account its impact on all sectors of the economy".[45] In other words, the study attempts a rigorous investigation of both the gross and the net impacts of the policies. The authors write:

> Increased use of RES has various effects on the economy, some of which are positive in terms of employment and economic growth, while others are negative. This study presents both gross and net effects. Broadly speaking, gross effects include only the positive effects in RES and RES-related industries, while net effects are the sum of positive and negative effects. For the net effects, all relevant economic mechanisms are considered.

3.5.9. These mechanisms include:

- Increased investments, operation and maintenance costs and biomass fuel supply for RES.
- Reduced investments, operation and maintenance costs in the conventional energy sector.
- Fossil fuel imports and use avoided.
- Increasing energy costs and their effects on the economy due to reduced competitiveness (industry) or reduced budgets for consumption (consumers and governments).
- Trade in RES technology and fuels among EU countries and with the rest of the world.[46]

3.5.10. *EmployRES* also posits three policy scenarios:

- No Policy for renewables support (NP). In this scenario all current policies are abandoned.
- Business as Usual (BAU). In this scenario the current (2009) renewables policies in the various EU states continue, but they are not augmented. This scenario is, the authors tell us, not adequate to meet the 2020 EU Renewables Directive, since it delivers 14% of EU final energy consumption in 2020, and 17% in 2030.
- Accelerated Deployment Policies (ADP), these stronger support mechanisms delivering 20% of EU FEC in 2020 and 30% by 2030.[47]

3.5.11. These scenarios for renewables deployment are combined with three further scenarios describing the EU's share of the world market for renewable energy technologies:

- Pessimistic Exports (PE). In this scenario the EU's market share falls from 69% in 2009 to 31% in 2030.
- Moderate Exports (ME). In this scenario the EU's share falls to 43%.
- Optimistic Exports (OE). In this scenario the EU's share falls only to 54%.[48]

3.5.1. A great deal hinges on these market share scenarios, which are described in the following chart:

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[45] Summary, *EmployRES*, p. 4.

[46] Summary, *EmployRES*, p. 4.

[47] Summary, *EmployRES*, p. 4.

[48] For outline see Summary, *EmployRES*, p. 4; but for details of percentage share see the main study, *EmployRES*, p. 124.

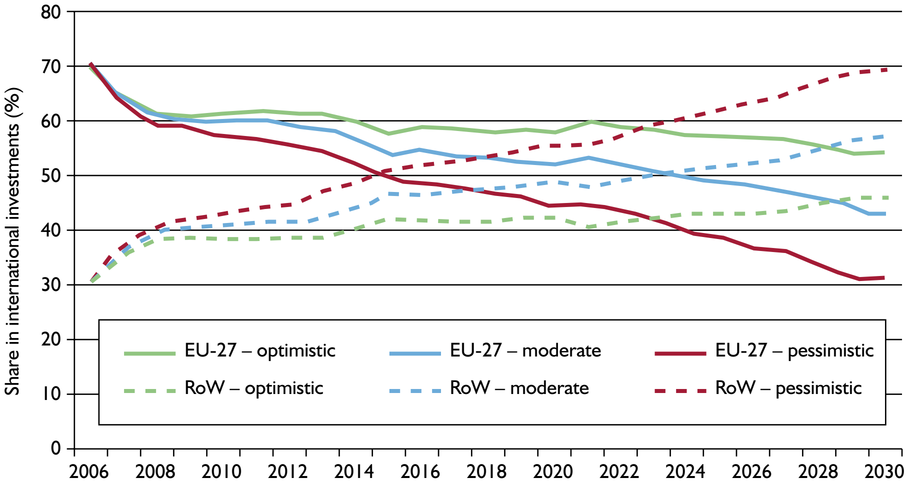

Figure 7: World market shares of the EU and the rest of the world (RoW) in the global cost components of RES technologies (weighted average of all technologies).
Source: EmployRES.[49] Chart redrawn by REF.

3.5.2. It is important to note that the empirical section of the chart shows that market share is declining, and all the predictive scenarios assume that this decline will continue, the variation between them being only in the rate of decline. This seems reasonable given the manifest comparative advantage enjoyed by China and India, amongst others, in certain areas of engineering, electronics, and manufacturing. The significance for net economic impact of a reduction in market share is twofold: firstly, if exports decline, then the EU loses the benefit of that income; secondly, the exports of other RoW countries will rise in part because of exports to the EU, therefore imposing an economic cost.

3.5.3. The following pair of charts describes the gross and net employment effects of RES policies in the overall EU economy, the gross effects being calculated from NEMESIS, and the net effects from both NEMESIS and ASTRA:

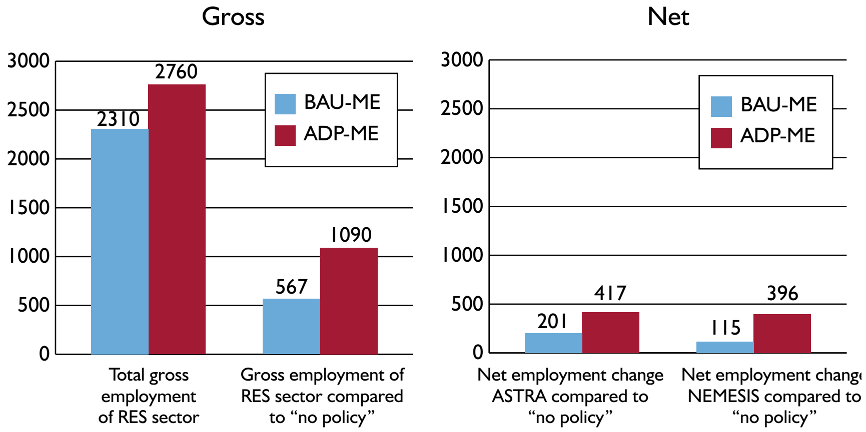

Figure 8: Employment effects by 2020 in the EU-27, showing the gross increase in jobs (1,000s) in the Renewable Energy Sources (RES) sector (left) and the net increase in jobs in the whole economy as a result of RES policies (right).
Source: EmployRES.[50] Chart redrawn by REF.

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[49] *EmployRES*, p. 125.

[50] Summary, *EmployRES*, p. 7. See also Figure 18, which gives in addition the net effects for 2010 and 2030. For the relevant section of the main text see pp. 127ff, where it is explained that the gross employment figures are derived from the NEMESIS model.

3.5.4. Of the left hand chart the accompanying text in the Summary remarks:

> Total gross employment in the RES sector in the EU-27 in 2020 will amount to 2.3 million people under the BAU-ME scenario and 2.8 million under the ADP-ME scenario. Compared to the hypothetical scenario in which all RES support policies are abandoned, the additional gross employment due to RES policies amounts to 0.6 million people for the BAU-ME scenario and 1.1 million people for the ADP-ME scenario. Total gross employment in the RES sector may increase by up to 3.4 million people by 2030 if there is an accelerated deployment policy combined with optimistic export expectations (ADP-OE).[51]

3.5.5. These are large numbers, and in the main text the authors observe that on this view the renewable energy industry would "become one of the very important sectors in terms of employment in Europe."[52] While such gross figures are of limited value in many respects, they do shed light on the rebalancing of the EU economies that is implicit in a planned and target-driven transition to renewables. A government mandated employee base on this scale has significant implications for energy prices, and thus for net economic effects in the longer term if these jobs are to be maintained permanently at non-market wages. Indeed, the marginal net employment effects reported by *EmployRES* in the right hand chart for both the ASTRA and the NEMESIS macroeconomic models above confirm the view that the cost of supporting renewables causes significant contraction in other parts of the economy due to, in the words of the study itself, "Increasing energy costs and their effects on the economy due to reduced competitiveness (industry) or reduced budgets for consumption (consumers and governments)."[53] Commenting on this suppressive effect the authors write:

> Sectors losing employment would suffer from the higher energy expenditures of households, the higher sectoral elasticities in response to higher goods prices driven by energy cost increases and the prevailing budget constraint of households. Examples would be the trade and retail sector as well as the hotels and restaurant sector.[54]

3.5.6. The effect on energy intensive users, the steel and chemicals industries for example, should have been mentioned here, but it is useful to be reminded that higher energy prices have an important indirect impact on service industries, and this is of particular importance to those considering impacts on lower income deciles, since such service industries, particularly the hospitality industry, have high rates of part-time workers and lower wages. **The implications for risk of hardship due to unaffordable energy should be obvious; the EU's work suggests that the policies may destroy jobs in exactly those areas where workers are already at risk of hardship due to low income.**

3.5.7. As might be expected, these effects are not evenly distributed across the EU-27, and the study helpfully provides gross and net employment effects analysed by member state. The following chart represents the gross employment impacts of the Additional Deployment scenario in conjunction with the Moderate Export scenario, employing the NEMESIS model.

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[51] Summary, *EmployRES*, p. 7.

[52] *EmployRES*, p. 140.

[53] Summary, *EmployRES*, p. 4.

[54] Summary, *EmployRES*, p. 26.

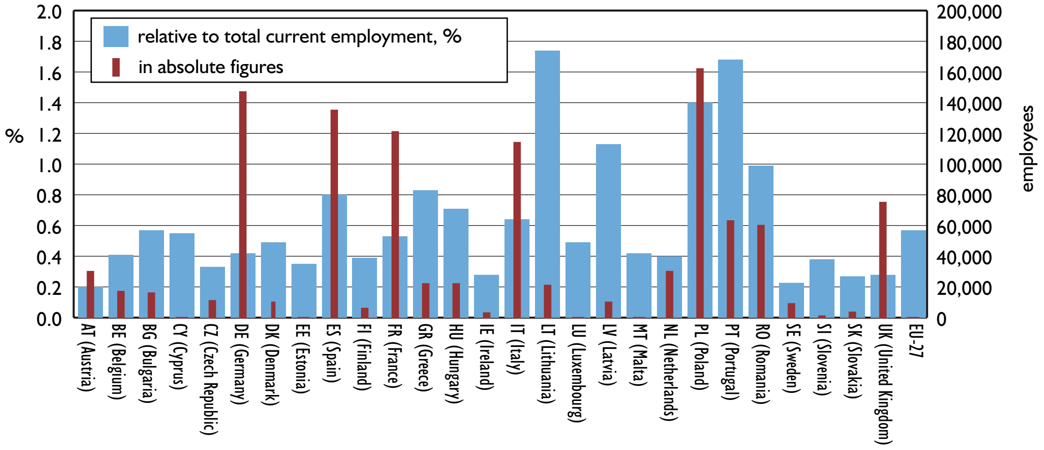

Figure 9: Relative and absolute differences in employment between Accelerated Deployment Policies and Moderate Exports (ADP-ME) scenario and the No Policy scenario for 2020, by countries and in relation to total employment in 2007.
Source: EmployRES.[55] Chart redrawn by REF.

3.5.8. Percentage change is indicated by the blue bars and the left hand axis, and absolute numbers by the red bars and the right hand axis. It is important to note that even the gross effects in comparison to No Policy are truly marginal for many member states. Gross employment figures analysed by member state are provided for only one scenario, which hampers consideration of the net effects to be discussed later, particularly in relation to the United Kingdom. However, this chart can be taken as indicating the approximate scales to be considered.

3.5.9. The net employment impacts on the EU-27 members are described in seven charts, three relating to the NEMESIS model, and four to ASTRA. The policy and export scenarios considered are Business as Usual – Moderate Exports (BAU-ME), Business as Usual – Optimistic Exports (BAU-OE), Accelerated Deployment Policies – Moderate Exports (ADP-ME) and Accelerate Deployment Policies – Optimistic Exports (ADP-OE). One scenario is omitted, NEMESIS ADP-OE, perhaps in error.[56] **In only one of the seven scenario combinations considered is there a net positive employment gain for the United Kingdom**, namely NEMESIS, ADP-ME (the gross scenario for which is described above), which shows a gain of approximately 2,500 jobs. **In all other scenarios charted the UK, alone of the EU-27, records net negative employment, ranging from a net loss of over 10,000 jobs to a net loss of over 30,000 jobs.** Bearing in mind the scale of the gross job creation shown for the ADP-ME scenario (approximately 70,000 jobs), it is clear that the economic impact of the EU renewables policies on the United Kingdom is significantly negative.

3.5.10. In the interests of concision, we will reproduce only four of the scenarios considered for both the NEMESIS and ASTRA macroeconomic models.

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[55] *EmployRES*, p. 135. The economic model employed is NEMESIS.

[56] *EmployRES*, pp. 156-185.

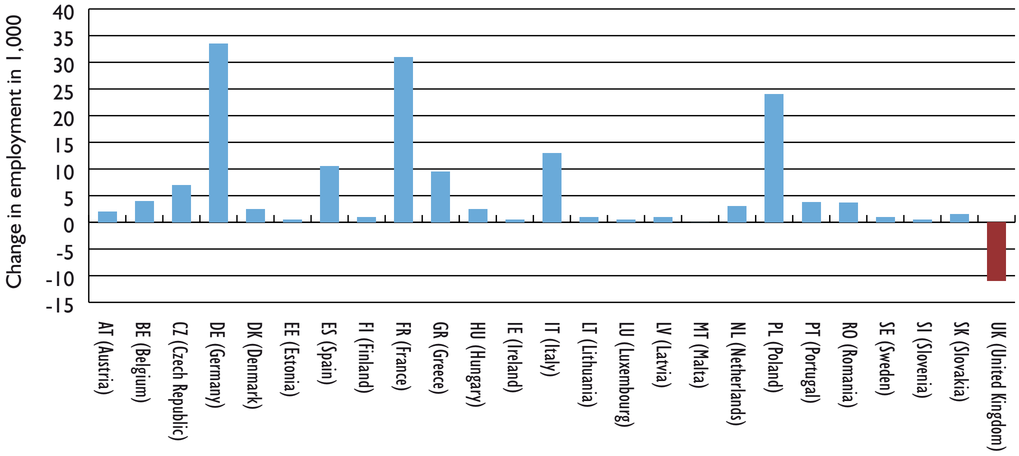

Figure 10: NEMESIS: Change in employment: Business as Usual and Optimistic Exports (BAU-OE) compared to No Policy.
Source: EmployRES.[57] Chart redrawn by REF.

3.5.11. Few EU states exhibit even modest net gains, most being marginal. The UK suffers a net loss of over 10,000 jobs.

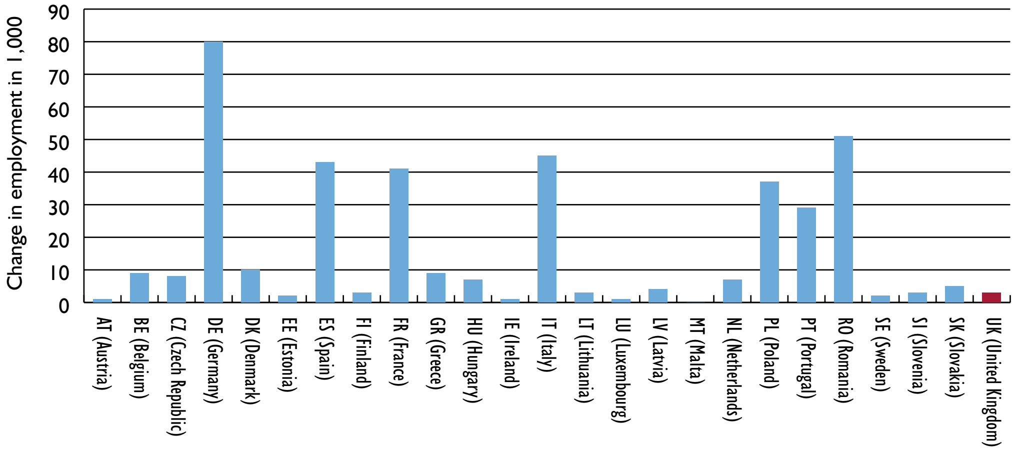

Figure 11: NEMESIS: Changes in employment: Accelerated Deployment Policies and Moderate Exports (ADP-ME) compared to No Policy.
Source: EmployRES.[58] Chart redrawn by REF.

3.5.12. This is the sole chart displayed in which the UK has as net positive employment gain, which can be estimated at approximately 2,500 jobs. The gains in competitor states such as Germany, France and Spain are significantly higher.

3.5.13. The findings in the ASTRA model are still less encouraging. Again we will consider only the optimistic export scenarios:

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[57] *EmployRES*, p. 159.

[58] *EmployRES*, p. 162.

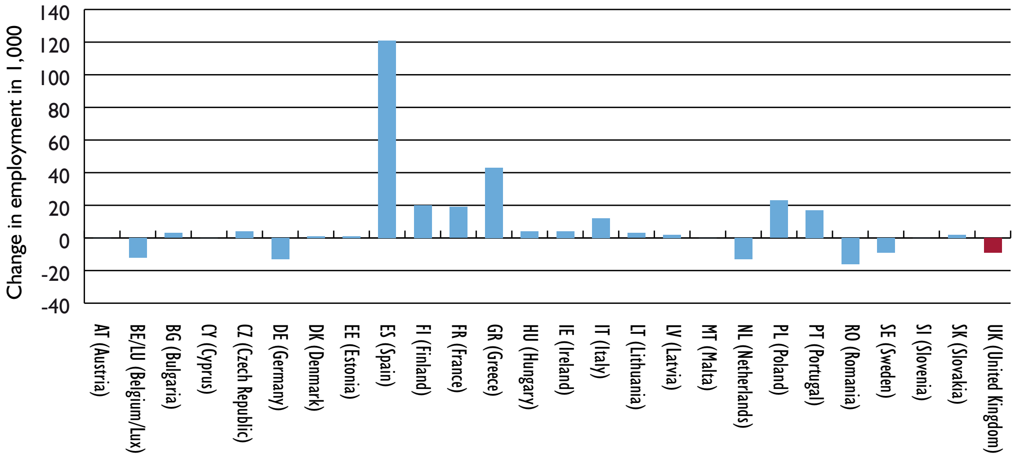

Figure 12: ASTRA: Change in employment: Business as Usual and Optimistic Exports (BAU-OE) compared to No Policy, 2020.
Source: EmployRES.[59] Chart redrawn by REF.

3.5.14. In this scenario many EU states suffer net negative employment effects, and the gulf between the winners and losers appears to be greater than before.

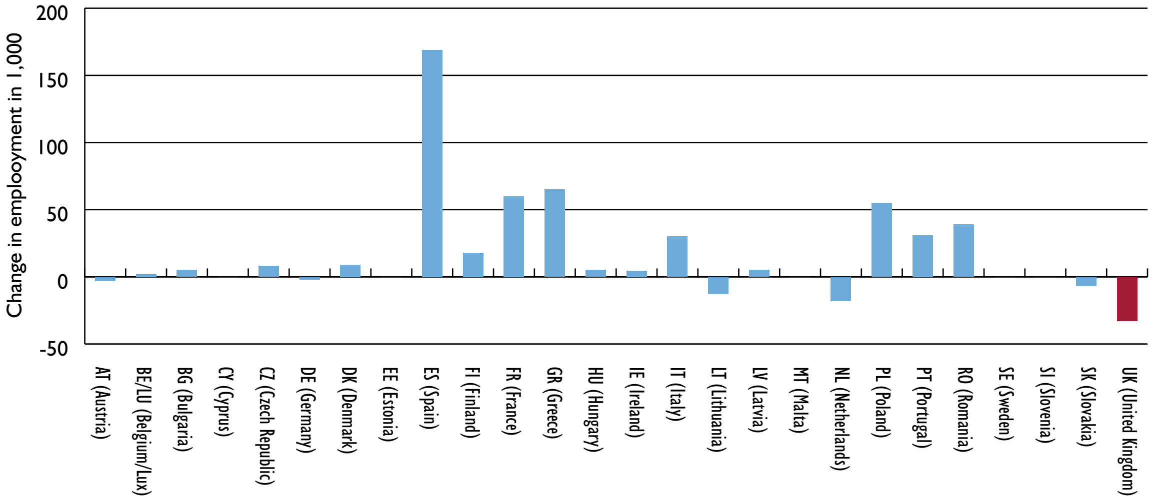

Figure 13: ASTRA: Change in Employment: Accelerated Deployment Policies and Optimistic Exports (ADP-OE) compared to No Policy, 2020.
Source: EmployRES.[60] Chart redrawn by REF.

3.5.15. The United Kingdom experiences net negative job effects of around 30,000 jobs, with the Netherlands also seriously affected. Other countries such as Spain fare better.

3.5.16. The headline figure for the EU offered in *EmployRES* is of 0.24% of net additional GDP as compared to the No Policy scenario in which current renewable energy policies are abandoned.[61] It is interesting to further note that the Summary also reports that, under the NEMESIS model, "Assuming an accelerated deployment policy combined with optimistic export expectations (ADP-OE) *net additional* GDP compared to the no-policy scenario would amount to 0.44% of GDP in 2030".[62] Reference to the useful chart comparing Gross Value Added and net GDP changes confirms this point:

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[59] *EmployRES*, p. 182.

[60] *EmployRES*, p. 185.

[61] *EmployRES*, Summary, p. 4.

[62] *EmployRES*, Summary, p. 6. See also the main study, p. 151.

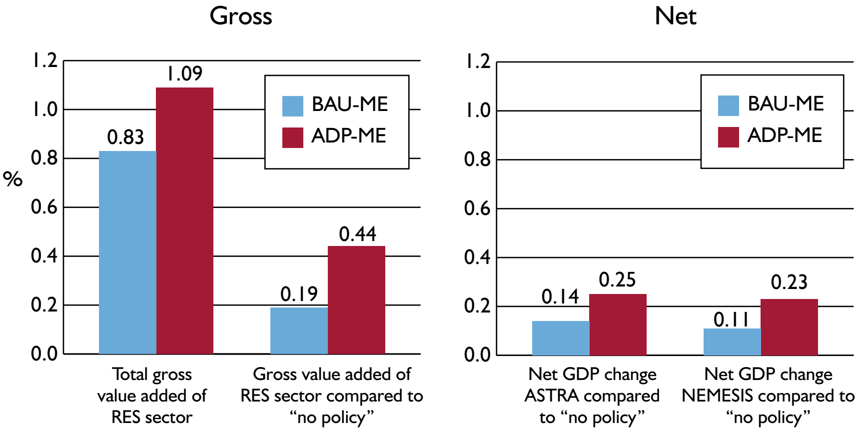

Figure 14: Economic growth effects by 2020 in the EU-27 showing the gross value added of the Renewable Energy Sources (RES) sector in the NEMESIS model (left) and the net GDP impact of RES policies (right) in both NEMESIS and ASTRA, both as a ratio of GDP. Both Business as Usual and Accelerated Deployment Policies are considered in relation to the Moderate Export scenario.
Source: EmployRES. Chart redrawn by REF.

3.5.17. These would appear to be small gains, well within the measuring error, and hardly proportionate to the economic and technological risks involved.

3.5.18. Viewed from the perspective of individual member states, the effects on GDP are also discouraging. The scenario and assumption combinations considered are the same as for net employment, though on this occasion the NEMESIS ADP-OE combination is present. All the results for the NEMESIS set show that the UK sees relative economic contraction, while the results for the ASTRA model show slight growth.

3.5.19. We can illustrate this with two charts for the most optimistic export scenarios. NEMESIS (Figure 15) indicates that while most EU states experience slight GDP growth as a result of the renewables policies, the UK experiences relative contraction, and ASTRA (Figure 16) shows that GDP growth is modest even under an optimistic export scenario.

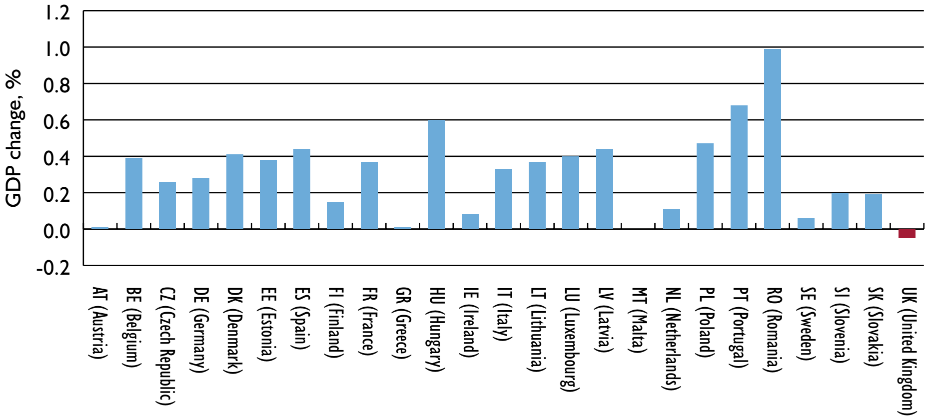

Figure 15: NEMESIS. Change in GDP: Accelerated Deployment Policies and Optimistic Exports (ADP-OE) compared to No Policy, 2020.
Source: EmployRES.[63] Chart redrawn by REF.

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[63] *EmployRES*, p. 164.

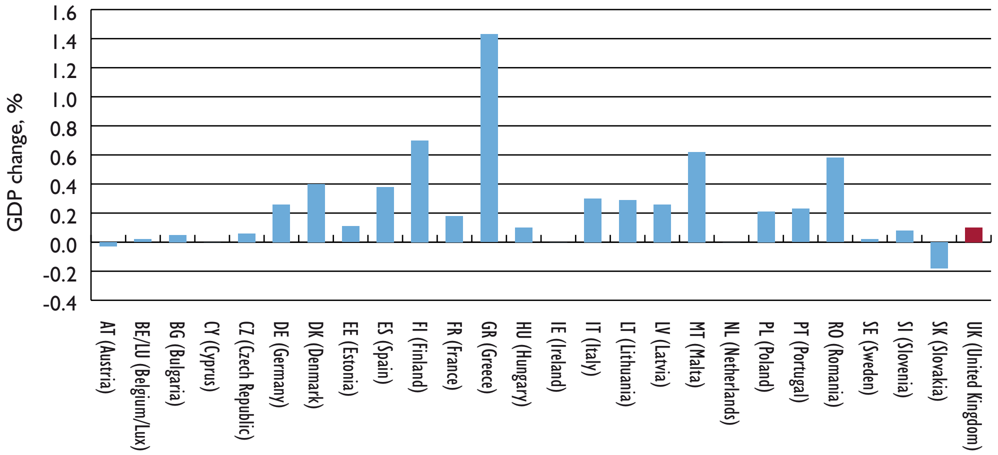

Figure 16: ASTRA: Change in GDP: Accelerated Deployment Policies and Optimistic Exports (ADP-OE) compared to No Policy, 2020.
Source: EmployRES.[64] Chart redrawn by REF.

3.5.20. In summary, the *EmployRES* modelling exercise shows that even in scenarios assuming optimistic European dominance of the world market for renewable energy technology the net employment effect for the United Kingdom will be negative, as rising energy prices cause economic contraction in other parts of the economy. Net employment effects in other EU states are varied, and clearly heavily dependent on optimistic assumptions with regard to exports to other EU states and the rest of the world.[65]

3.5.21. Effects on GDP are more mixed, with the NEMESIS and ASTRA models at slight variance. The authors themselves note that the results show only “slight” overall growth even in scenarios making optimistic assumptions with regard to renewable energy equipment exports (0.25–0.26% in 2020).[66] For some states, notably the UK, the prospect is for either relative economic contraction or only modest growth. The unconsidered pessimistic export scenarios would presumably produce results that were still less encouraging.

3.5.22. We can summarize these findings in the following table, where the numerical values reported are measured optically from the charts, and are therefore approximate:

Table 5: Summary of results for EmployRES’s estimated net employment and GDP effects of renewable energy policies in the United Kingdom to 2020, compared to No Policies.
Source: EmployRES (2009).

	Macro-economic Model: ASTRA		*Macro-economic Model: NEMESIS*	
	Business as Usual v. No Policy	**Accelerated Deployment Policies v. No Policies**	**Business as Usual v. No Policies**	**Accelerated Deployment Policies v. No Policies**
Pessimistic Exports	Not considered	Not considered	Not considered	Not considered
Moderate Exports	Jobs: – 10,000	Jobs: – 31,000	Jobs: – 11,000	Jobs: + 2,500
	GDP: + 0.07%	GDP: + 0.1%	GDP: – 0.01%	GDP: – 0.03%
Optimistic Exports	Jobs: – 10,000	Jobs: – 31,000	Jobs: –11,000	Jobs: Not considered
	GDP: + 0.07%	GDP: + 0.1%	GDP: – 0.01%	GDP: – 0.03%

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[64] *EmployRES*, p. 184.

[65] Summary, *EmployRES*, p. 27.

[66] Summary, *EmployRES*, p. 24.

3.5.23. Even such rewards as obtained under the optimistic scenarios do not seem commensurate to either the scale of the endeavour or the implied risks. Put another way, if economic reform on the scale proposed is to be undertaken, with all its attendant technological, social and financial dangers, there should be a potential for significant gains to justify the adventure. However, the *EmployRES* study suggests that though the hazard is large, the prizes are minor at best.

3.5.24. It is important to note also the *EmployRES* study gives grounds for suspecting that employment losses will occur not only in energy intensive industries such as paper-making or chemicals, but, perhaps unexpectedly, in sectors such as hospitality, where part-time and low income workers are present in significant numbers. This reflects not only the more or less straightforward effects of increasing energy prices on the business that consume the energy, but also the general reduction in discretionary spending and hence spending in hotels and restaurants and similar industries.

3.5.25. In overview, the Commission's own analysts give little reason for complacency in regard to the net employment and income effects of current energy policies at an EU level, and considerable justification for concern at the likely consequences for the United Kingdom.

3.5.26. Bearing in mind the total costs calculated above for UK renewable electricity subsidies alone of around £15 billion a year, equivalent to 1% of current GDP, the costs seem all but certain to contribute to economic stagnation and loss of employment.

3.5.27. Such an effect would create exactly the combination of rising energy prices and falling household incomes that would indicate sharp rises in risk of hardship across the entire population.

4. Energy Policies and Government Estimates of Their Impacts

4.1. Energy Policies

4.1.1. One of the difficulties of quantifying the cost impacts of energy policies on consumers is that the policies, which arise both from EU Directives and UK national initiatives, are both numerous and overlapping.

4.1.2. Fortunately, the EU requires member states to report regularly to the European Commission on energy policies, and an EC-funded project, MURE (Mesures d'Utilization Rationelle de l'Energie), provides a qualitative database of measures undertaken by each country.[67] This database reveals the UK has reported the startling number of sixty-three policy measures to address the energy and climate change agenda. A summary of this list is given in Appendix 1.

4.1.3. Establishing the consumer costs of all these measures is beyond the scope of this study. However, the major energy and energy conservation measures are listed in the following table.

Table 6: Major UK renewable energy and energy conservation policy measures funded by levies on energy suppliers or general taxation.

Source: MURE, DECC. Cost estimates for levy-funded obligations are from Hansard, except where otherwise stated.[68]

Renewables Obligation (RO)[69]	An obligation on electricity suppliers to obtain an annually increasing proportion of electricity supplied from renewable sources. The costs of the RO are met by a levy on electricity that is administered by Ofgem, and has cost £7.3 billion to date.
Feed-in Tariff (FiT)	An obligation on electricity suppliers to pay specific, index-linked, tariffs for generation and export of electricity from small-scale renewable generators. The costs of the FiT are met by a levy on electricity consumers. The cost to date is approximately £20 million, and has been capped at £867 million over the period 2011/12 to 2014/15.
EU Emissions Trading System (ETS)	A cap and trade system that seeks to limit CO_2 emissions from power plants by putting a price on those emissions. These costs are passed through to consumer bills. This scheme guarantees and also caps the emissions savings within the EU, with the result that other emissions reducing policies, such as the Renewables Obligation and the FiT add additional cost, but do not add additional savings.
Carbon Emissions Reduction Target (CERT)[70]	An obligation on large domestic energy suppliers to make savings in CO_2 emissions of households by promoting energy savings measures. The costs of these measures are passed through to consumer bills. The costs to date from CERT and its predecessor policy, the Energy Efficiency Commitment, amount to £5.4 billion.
Community Energy Savings Programme (CESP)	An obligation on energy suppliers and electricity generators to deliver a package of energy efficiency measures in low area incomes on a whole-house, whole street basis. The cost to date is £200 million.
Warm Home Discount Scheme	This is a four-year scheme running from 1 April 2011 which requires domestic energy suppliers to help low income households with energy costs. The scheme is financed via a levy on domestic electricity bills amounting to approximately £1.135 billion over the four years. The scheme is administered by DECC and Ofgem.

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[67] http://www.isisrome.com/mure/index.htm

[68] See Lord Marland answer to Parliamentary Question on Levy Funded Energy Costs *Hansard*, 25 Oct 2011: Columns WA126-WA127. http://www.publications.parliament.uk/pa/ld201011/ldhansrd/text/111025w0001.htm

[69] http://www.ofgem.gov.uk/Sustainability/Environment/RenewablObl/

[70] http://www.decc.gov.uk/en/content/cms/funding/funding_ops/cert/cert.aspx

Warm Front	A Government programme offering grants to improve energy efficiency in privately owned properties for people on certain income related benefits. The programme is funded out of general taxation and is administered by DECC. The costs will amount to £110 million in 2011/12.[71]
Renewable Heat Incentive	A Government funded scheme that is designed to provide financial support for renewable heat generators and producers of biomethane. The first phase, which is for larger scale, non-domestic heat, has been delayed following European Commission concerns that the proposed level of support for large biomass plant was too generous.[72] The scheme is funded from direct taxation, and will cost approximate £2 billion a year in 2020.[73]
Renewable Heat Premium Payment Scheme	A short-term interim measure pending full introduction of RHI for domestic heat generation funded from general taxation. £15 million has been set aside for this scheme which runs from 1 August 2011 to March 2012.

4.2. Energy Policy Impacts

4.2.1. The principal orientation point for consideration of the UK Government's own estimate of the impacts of current policy is the Department of Energy and Climate Change's *Estimated impacts of energy and climate change policies on energy prices and bills*, which was published in July 2010.[74] However, this document, which we shall refer to as *Estimated Impacts* from this point onwards, is now dated, in that funding the Renewable Heat Incentive has been transferred to general taxation (the original plan was for a levy on fossil fuels for heat), thus very significantly reducing the burden on bills, and Government is currently consulting on revisions to the bands of the Renewables Obligation that may bring about modest reduction in consumer costs.[75]

4.2.2. It may be added that the levels of support offered under the Feed-in Tariff (FiT) have been revised downwards once, in relation to larger solar and some other technologies, and Government is currently consulting on further revisions, this time halving support for small solar. Further reductions to other FiT technologies seem likely.

4.2.3. Nevertheless, since the 2011 Annual Energy Statement has yet to be published, *Estimated Impacts* remains the only comprehensive attempt by Government itself to analyse and assess these matters. In certain respects the document is unsatisfactory, one of the most significant points being the tendency to set off predicted savings against costs, thus obscuring the impacts of policies on prices and bills. While it is not unreasonable for Government to argue that they hope that such an offsetting will be largely successful, it would have been more helpful and generally transparent for cost-imposing policies to be considered in isolation at the outset of the text, and only then discuss the hoped for net effect.

4.2.4. The assessment of the impact of the Carbon Emissions Reduction Target (CERT) policy on domestic bills provides an example of this. *Estimated Impacts*, gives the impact as +£6 and –£7 for the average domestic gas and electricity bill respectively, thus suggesting a saving of £1 for a dual fuel customer. This contrasts with another Government estimate that calculated that CERT

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[71] http://www.decc.gov.uk/en/content/cms/news/pn11_37/pn11_37.aspx

[72] http://www.decc.gov.uk/en/content/cms/meeting_energy/renewable_ener/incentive/incentive.aspx

[73] Estimate from Committee on Climate Change, Renewable Energy Review (2011), 136. See: http://www.theccc.org.uk/reports/renewable-energy-review.

[74] DECC, *Estimated Impacts of Energy and Climate Change Policies on Energy Prices and Bills* (July 2010). URN 10D/719.

[75] DECC, *Consultation on Proposals for the Levels of Banded Support under the Renewables Obligation for the period 2013–17 and the Renewables Obligation Order 2012* (October 2011). URN 11D/876.

would put £61 on the bill of the average dual customer on the gas grid who receives no energy savings measures under the CERT scheme.[76]

4.2.5. Nevertheless, the document is informative in various ways, not least because it recognizes in very clear terms that the policies are potentially regressive in their effects:

> A greater burden of the increase in bills falls on lower-income households with respect to the share of income spent on energy bills.[77]

4.2.6. Furthermore, the text also acknowledges that the ability of lower-income households to access the offsetting energy efficiency measures and subsidized renewable energy options is limited. For example, while the document places much emphasis on the ability of improved standards in household appliances (fridges, freezers, washing machines, tumble driers and so forth) to drive down domestic energy consumption, and expresses the hope that the "Products Policy" can save £130 annually in 2020,[78] DECC also writes that:

> Energy and climate change policies are likely to have other costs and benefits that will impact energy consumers outside their electricity and gas bills, for example, through costs of appliances due to changes in energy efficiency standards.[79]

4.2.7. In other words, the higher efficiency standards required of domestic appliances will increase the cost of those devices, with obvious implications for those households on lower incomes, who might struggle to afford the new equipment and may decide against purchase.

4.2.8. Similarly, DECC's analysts write in the main body of their text that:

> By 2020 it is estimated that households will see a decrease in bills by an average of approximately 25% if they take up both a renewable energy and insulation measure, if only an insulation measure is taken up bills will fall by 7% on average, compared to the same bill in 2020 had they not taken up the measure.[80]

4.2.9. However, in the footnote to this sentence they remark:

> It should be noted that only a very small proportion of households (just over 1%) are assumed to receive both a renewable energy measure and an insulation measure as a direct result of climate change and energy policies […].[81]

4.2.10. We can infer, therefore, that the high 25% saving will be accessible only to those who have the capital to take up both insulation and an expensive renewable energy measure. Lower income households are more likely to be the beneficiaries of the insulation measure, if anything, and therefore will be saving 7% at best.

4.2.11. As DECC remarks:

> Policies that drive energy efficiency, such as CERT, CERT Extension, the Community Energy Saving Programme (CESP) and Future Supplier Obligation (SO) will therefore lead to transfers of benefits from those who do not take up measures but pay for the costs of these policies through their energy bills to those who do take up measures.[82]

4.2.12. The directional character of these transfers and the general implications for the population wide distribution of costs is evident in following department chart:

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[76] Paving the Way for a Green Deal: Extending the Carbon Emissions Reduction Target Supplier Obligation to December 2012. http://www.decc.gov.uk/assets/decc/consultations/certextension/certextgovresponse.pdf

[77] *Estimated Impacts* (2010), 3.

[78] *Estimated Impacts* (2010), 31.

[79] *Estimated Impacts* (2010), 4.

[80] *Estimated Impacts* (2010), 15.

[81] *Estimated Impacts* (2010), 15.

[82] *Estimated Impacts* (2010), 13.

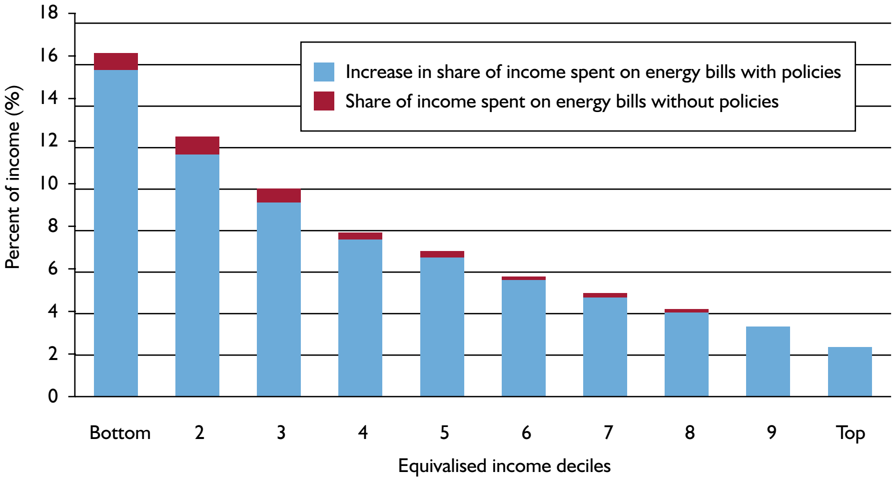

Figure 17: Energy Bill as a Percentage of Income in 2020, with and without energy and climate change policies.
Source: DECC.[83] Chart redrawn by REF.

4.2.13. Commenting on this plot, DECC remarks:

> Those households in the bottom income decile are estimated to see their expenditure on electricity and gas increase by around 1% of income in 2020 as a result of energy and climate change policies.
>
> By contrast, those households in the highest income deciles see a slight fall in energy bill as a proportion of income as it is assumed, under current policies, that they are more likely to take up renewable or insulation measures due to associated up front financial cost of take up.[84]

4.2.14. Evidently, the department recognizes that current policies have a significantly regressive impact, with greater proportional effects on the lower income deciles, and a wealth transfer from lower to higher deciles. It is interesting to note that careful examination of the charts shows that 80% of the population see expenditure on energy rise as a fraction of income, so the beneficiaries are concentrated in the top two income deciles.

4.2.15. In addition, DECC remarks on the range of impacts represented by the average figure charted above for each decile:

> Households that receive insulation *or* renewable measures in the bottom income decile see the largest decrease in bills accounting for just under 1% of their income. However, without measures their bills rise by about 2% of income. This could potentially include over half of households in the bottom income decile.[85]

4.2.16. That is to say, while the *average* increase for the lowest decile is 1% of income, half of that decile could see energy expenditure increase by as much as 2% of income. Since this decile accounts for a large fraction of those at highest risk of hardship due to energy costs this is a highly undesirable impact.

4.2.17. Furthermore, it is critical to recognize that this chart is grounded in DECC's assumption that the cost-imposing policies will be almost entirely offset on average by energy saving policies, resulting in a net increase of only 1% on the *average* bill in 2020.[86] Should such policies be less successful than anticipated, the energy bill will comprise a very much larger share of incomes across the entire population.

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[83] *Estimated Impacts* (2010), 15.

[84] *Estimated Impacts* (2010), 14.

[85] *Estimated Impacts* (2010), 16.

[86] *Estimated Impacts* (2010), 3, 6.

4.2.18. In fact, there are widespread concerns as to the realism of Government expectations with regard to energy efficiency. The most prominent of these is the recently leaked letter from the Prime Minister's advisor on energy, Ben Moxham, in which he remarked that "we find the scale of household energy consumption savings calculated by DECC to be unconvincing."[87] We agree with this conclusion.

4.2.19. Indeed, there are indications of similar concern in other sectors of Government, and even in DECC itself. When answering questions in the House of Commons on the 4th Carbon Budget on 17th of May the Secretary of State for Energy and Climate Change, Mr Huhne, made repeated references to the importance of ensuring that the environmental policies returned "value for money", presumably to the subsidizing consumer, or in the case of the Renewable Heat Incentive, the taxpayer. This new emphasis is consistent with increasing signs that the Treasury is taking a close interest in the burdens imposed by instruments such as the Renewables Obligation and the Feed-in Tariff, for example in the *Control Framework for DECC levy-funded spending* (March 2011).[88]

Table 7: DECC Statement of Energy Levy Spending Limits.[89]

Policy	*2011-2012 (£M)*	*2012-2013 (£M)*	*2013-2014 (£M)*	*2014-2015 (£M)*
Renewables Obligation	1,764	2,191	2,615	3,203
Feed-in Tariffs	80	161	269	357
Warm Home Discount	250	275	300	310

4.2.20. However, this table, which is reproduced from Treasury's report, omits other energy levies, such as CERT and CESP, and this is significant since CERT in particular has costs of the order of £2 billion in 2011–2012.

4.2.21. Given that the scale of the burdens implied by environmental policies is considerable, and even DECC's own response to the *Control Framework* admits that the annual cost of the RO alone will be £3.2bn a year as early as 2014/15, Treasury's engagement comes as no surprise, and their decision to limit the scope of DECC's levy funded spending is clearly in the public interest, and to be welcomed. However, since Treasury controls VAT on such levy-funded spending it can itself contribute to the alleviation of that burden, and we recommend that it does so.

4.3. Electricity and Gas

4.3.1. While *Estimated Impacts* is an important guide to policy effects on prices and bills, Mr Moxham's letter in part supersedes it, since it reports DECC's latest thinking, which was unpublished at the time the present study went to press. That emerging view takes into account the reduced impact on gas bills, due to the funding of the RHI from general taxation, and incorporates various remarks on the Electricity Market Reform package:

> **DECC's analysis finds:**
>
> - Our policies would have a relatively small impact on household gas prices
> - Our policies would increase household electricity prices by 25% in 2015 and 30% in 2020 compared to what they would have been in the absence of policies

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[87] The full text of the document is available at: http://www.telegraph.co.uk/earth/greenpolitics/8741779/Advisers-letter-to-David-Cameron-on-energy-and-climate-policies.html.

[88] See: http://hm-treasury.gov.uk/d/control_framework_decc250311.pdf. For DECC's comments see: http://www.decc.gov.uk/assets/decc/What%20we%20do/UK%20energy%20supply/Energy%20mix/Renewable%20energy/1691-qa-info-levy-funded-spending.pdf

[89] DECC, *Control Framework for DECC levy-funded spending: Questions and Answers* (29 March 2011. URN 11D/675).

- The contribution of individual policies to the 30% policy-driven price increase estimated for 2020 is as follows: i) A third of the total cost comes from carbon pricing policies – both HMT's carbon price floor and the carbon price derived from the EU emissions trading scheme. ii) A third comes from the Energy Company Obligation – the successor policy to CERT, to be implemented from late 2012 alongside the Green Deal, mandating energy companies to install hard-to-treat energy efficiency measures and make fuel poor households more energy efficient. iii) A fifth of the total policy cost comes from Electricity Market Reform's new long-term contracts. iv) A fifth comes from price support for renewables under the Renewables Obligation. v) Around 5% of the total policy costs comes from small-scale feed-in tariffs.

4.3.1. It is interesting to note that in spite of EMR the effects on household bills are little changed in scale from those estimated in 2010 on the basis of then current policies, which were estimated as causing a 33% increase.[90] This is consistent with our view that revisions to renewables target delivery mechanisms can make relatively little difference to the overall cost so long as the fundamentals of the technologies concerned remain the same. That is to say, so long as capital and grid integration costs remain high and load factors are low, meeting the targets will require subsidy and other costs at the levels currently evident. Improved policy design may offer some marginal savings, but without radical reductions in fundamental costs only a reassessment of the targets can bring significant relief.

4.3.2. Nevertheless, the fact that DECC now believes its policies have negligible effects on the price of gas in 2020 do show that the decision to fund the Renewable Heat Incentive from general taxation rather than a levy on fossil fuels clearly has reduced the consumer burden, by transferring it to taxpayers, and while its overall magnitude remains very large (£2bn in 2020 according to the Committee on Climate Change[91]) the effect is now progressive and the burden carried by sources that can better afford it.

4.3.3. In an earlier work by the present authors, *The Renewable Heat Incentive: Risks and Remedies* we concluded from analysis of DECC data that "it seems that funding the RHI alone might consume around 2% of the annual income of the poorest households in 2020, funds that will go towards reducing the bills of the richest households".[92] Indeed, we found that the skewed distributional effect suggested that the lower three deciles would on average see RHI impacts of £135 to £184 on their bills, as opposed to the £94 which they might have seen if the costs were imposed equally across all income bands. We concluded that it would be unwise, indeed unjust, for Government to proceed with the levy-funded design and we suggested funding from tax as an alternative.

4.3.4. While there are good reasons for being concerned at the macroeconomic impact of a £2 billion tax burden, which will put a brake on growth and reduce incomes and employment elsewhere in the economy, the general principle of funding experimentation with renewables, if not the attainment of arbitrary targets, from tax rather than levies on consumers applied via the competitive element of a market seems us to sound and deserving of wider application.

4.3.5. However, we remain concerned that the DECC analysis, reported in Mr Moxham's note, may be concealing effects on the gas price.

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[90] *Estimated Impacts* (2010), 6.

[91] Committee on Climate Change*, The Renewable Energy Review* (May 2011), 136.

[92] John Constable, Lee Moroney, *The Renewable Heat Incentive: Risks and Remedies* (Renewable Energy Forum: London, 2010), 7–8.

4.4. Energy Expenditure and GDP

4.4.1. A useful but overlooked metric for assessing risk of energy related hardship, and the probable impact of policies, can be found in the proportion of Gross Domestic Product spent on energy. Higher proportions and a rising trend would indicate a probable increase in risk of hardship.

4.4.2. There should be no doubt that policy costs are relevant even in such a macroscopic context. Taking the Renewable Obligation electricity policy costs alone described above, we arrive at a total of over £15 billion a year in 2020, composed of subsidy, integration costs, and VAT, which is equivalent to over 1% of current GDP.

4.4.3. Since the United Kingdom currently spends around 8.5% of GDP on energy this is a highly significant increase, with implications for risk of hardship.

4.4.4. The following chart plots expenditure on energy as a percentage of GDP for the United Kingdom and the United States from 1970 to 2007 (US) and 2010 (UK), and also includes the frequency of those judged to be in fuel poverty according to the current definition:

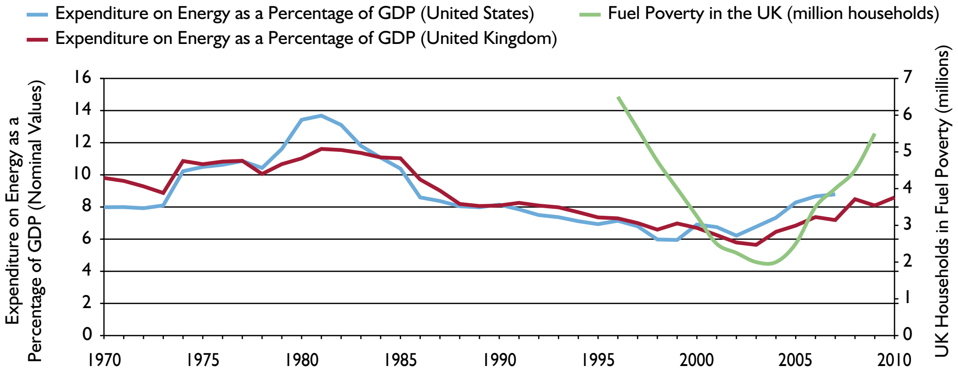

Figure 18: United States and United Kingdom Expenditure on Energy as a percentage of GDP (blue and red lines, respectively, left hand axis), and millions of households in fuel poverty in the UK according to the standard definition (green line, right hand axis).
Source: DECC, US Department of Commerce (Bureau of Economic Analysis), US Census Bureau, Measuringworth.[93] Chart: REF.

4.4.5. The two decades during which the energy expenditure to GDP ratio fell coincides with a prolonged period of prosperity, and, we would argue, indicates decreasing risk of energy hardship. By contrast, the reversal of that trend between 2002 and 2003 is, we suggest, a reasonable measure of increasing risk of hardship over the entire population.

4.4.6. The trends in the United States and the United Kingdom are very similar, suggesting that the external market prices of energy are a major driver of variation in this measure, a point that underlines the fact that government influence over energy prices to consumers is limited. Though this reminds us that we should be realistic about what government can do with regard to the price element in risk of hardship, it also serves to emphasize that government should be cautious in adding to the energy price burden, since it cannot be sure that market variables beyond its control may make this addition intolerable.

4.4.7. In support of our suggestion that this ratio is a useful metric of risk of hardship we note that the traditional calculation of "fuel poverty" numbers produces a curve that is also correlated with the energy expenditure to GDP ratio in both countries, an effect that results from the traditional calculation's sensitivity to price. Indeed, the exaggerated nature of that curve arguably confirms

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[93] UK energy expenditure figures are drawn from DECC (*Digest of United Kingdom Energy Statistics*). US GDP obtained from the US Department of Commerce (Bureau of Economic Analysis). US Energy Expenditure is from the US Census Bureau (http://www.census.gov/compendia/statab/cats/energy_utilities.html). UK Nominal GD: MeasuringWorth (http://www.measuringworth.com/aboutus.php).

suggestions made on other grounds that the traditional calculation is, indeed, oversensitive to price.[94]

4.4.8. Examination of the ratio of energy spending to GDP leads us to conclude, as mainstream economics would argue from first principles, that "fuel poverty", or actual hardship and increasing risk of hardship, is fundamentally caused by the relation between income and energy price, the latter being largely controlled by factors external to the society concerned.

4.4.9. That is to say, risk of energy hardship and cases of actual energy hardship result from the relationship between incomes and energy prices. Fluctuations in risk of hardship in the short term are attributable to fluctuations in these variables. That is to say, over shorter timescales they are the causes of those matters of concern generally discussed under the title "fuel poverty".

4.4.10. The following chart shows Gross Domestic Product per household (in 2006 prices) and the RPI for fuel used for heating and lighting (indexed to 2006).

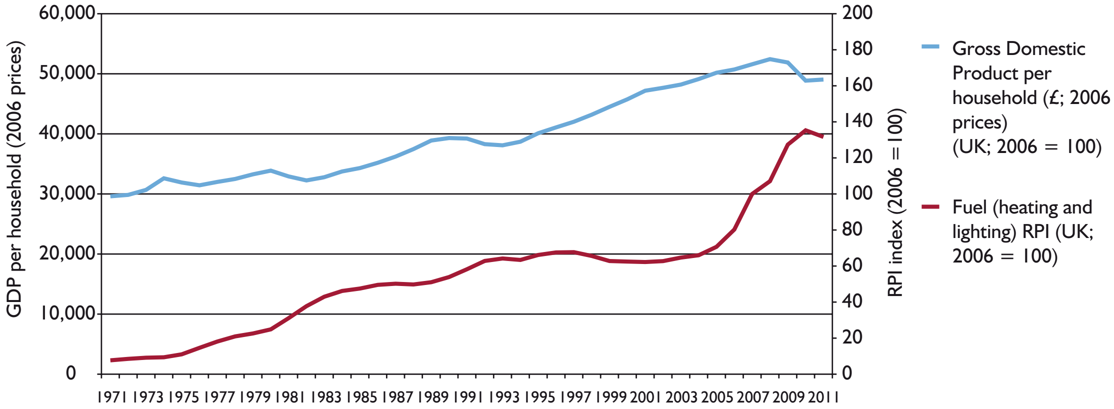

Figure 19: UK Gross Domestic Product per household (£, 2006 prices) and the Retail Price Index for Fuel used for heating and lighting (UK: 2006 = 100).
Source: DECC. Chart: REF.

4.4.11. We adopt GDP per household as a reasonable approximation to national wealth at, as it were, street level. The RPI of fuel used for heating and lighting tracks the general increase over the period 1970 to the present day.

4.4.12. Evidently, fuel prices increase relative to national income over the period 1970 to the early 1990s, when prices stabilize or even decline, until 2003, after which we see a very significant increase in fuel prices relative to national income.

4.4.13. We suggest that there is reason to infer that the stable prices in the period 1991 to 2003 account for the stable growth evident in the figures for GDP per household, with the slightly increasing trend thereafter possibly contributing to the simultaneous reduction in growth rate.

4.4.14. It is particularly important to note the clear reduction in prices from 1997, almost certainly due in part to the introduction of the reduced rate of Value Added Tax, at 5% (1st of September 1997), and the growing effects of competition, which was first introduced to the gas markets as a result of the Gas Act of 1995, though not begun until 1996, and then the electricity markets. Liberalization was complete in gas by May 1998 and electricity in May 1999.[95]

4.4.15. While the nearly decade long period of comparatively low prices is correlated with steady economic growth it is interesting to note that GDP growth continued even after energy prices began to increase sharply in 2003–2004.

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[94] For further comments on this oversensitivity from a different perspective, see John Hills, *Fuel Poverty: The problem and its measurement* (CASE Report: October, 2011), 14, 104–105.

[95] http://www.decc.gov.uk/assets/decc/11/stats/publications/dukes/2296-dukes-2011-annex-d.pdf

4.4.16. As an index of population-wide risk of energy hardship the chart suggests that the period 1991 to 2003 saw risk of hardship declining across the population, and the very sharp increase in energy prices after 2003 indicates a period when it was rapidly increasing in spite of continued growth. The faltering of growth in combination with high prices is a clear alarm signal.

4.5. Policies as Buffers against Fossil Fuel Price Volatility

4.5.1. It is often suggested that the subsidies to renewables will create an indigenous source of energy supply that buffers the UK against rising fossil fuel prices. However, this argument, although intuitively attractive, appears questionable for a number of reasons.

4.5.2. As a preliminary orientation, we should recall that Final Energy Consumption to which the EU Renewables Directive refers is approximately 1,700 TWh, which may be put in perspective by recalling that the UK consumes about 330 TWh of electricity. The 15% target therefore requires that approximately 260 TWh of that energy should come from renewable sources by 2020, with about 120 TWh of that coming from electricity, a division of burden made probable by the United Kingdom's limited access to biomass for heat and transport.

4.5.3. Even if we are to assume that this target can be met, and very few believe that it can, the UK would still be seeking the remaining 85% (less some nuclear input) from the fossil markets. Should fossil fuel prices rise dramatically, it is conceivable that the 15% renewable share would provide some degree of saving in comparison, but it should be recognized that the saving would have to be such as to exceed the total cost of supporting renewables *up to* that point, not just *at* that point. Since the cost of renewables support is very high indeed, this seems improbable.

4.5.4. Still more significantly, it should be remembered that while rising fossil fuel prices might make renewables comparatively attractive, they will not make them cheaper. In other words, in a world of high fossil fuel prices the consumer will be facing much higher energy bills. The question is whether the subsidy invested in the renewables industry up to that point leads to a sector that is competitive with fossil fuels and can rapidly, and without further subsidy, expand to displace fossil fuels. Unfortunately, since subsidies shelter industries from competition they also tend to infantilize, and there are good reasons for doubting whether a subsidized renewables sector would be sufficiently vigorous and intrinsically viable to take advantage of the opportunity created for that sector by very high fossil fuel prices.

4.5.5. Furthermore, due to the highly variable nature of renewables outputs on an annual basis, the quantum of fossil energy required by the UK could vary considerably from year to year,[96] a demand variation that would have to be met at potentially disadvantageous prices from the international spot markets, rather than through long term contracts. This is a major consideration that does not appear to be adequately considered in government thinking.

4.5.6. Overall, it seems likely that the renewables policy will offer only a very weak buffering against fossil fuel prices, and that even if these rise to very high levels the UK would be exposed to the costs of the environmental policies *in addition* to, not *instead of*, rising fossil prices.

4.5.7. In regard to this it is interesting to note that the BRE's modelling for the Committee on Climate Change found that in the High-High fossil price scenario, while the baseline fossil fuel price increase took 5.6 million households into fuel poverty on the current definition this number rose to 7.4 million when carbon price and renewable electricity were taken into account.[97]

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[96] See, for example, the variations in wind output per MW of capacity recorded between in the United Kingdom between 2003 and 2010: http://www.ref.org.uk/publications/229-renewables-output-in-2010.

[97] BRE, *The effect of the Committee on Climate Change's proposed carbon budgets on fuel poverty* 28.11.08), 19. http://www.theccc.org.uk/pdf/The%20effect%20of%20the%20CCC's%20proposed%20carbon%20budgets%20on%20fuel%20poverty%20(BRE).pdf

5. Key Consumer Vulnerabilities: Electric Heating

5.1. Since the Government's prudent decision to fund the Renewable Heat Incentive (RHI) from general taxation, rather than from a levy on fossil fuels, current environmental policies are unlikely to have very significant direct impacts on gas prices to consumers, and thus to have as great a bearing on risk of hardship and actual hardship due to affordability of energy for heating.

5.2. However, due to the high costs of electricity subsidies designed to meet the EU Renewables Directive, and other policies addressing the climate change agenda, there is a considerable level of concern with regard to households that are dependent on electricity for their sole source of heating. Approximately two million households in Great Britain use electricity as their primary energy source, amounting to about 10% of the total.

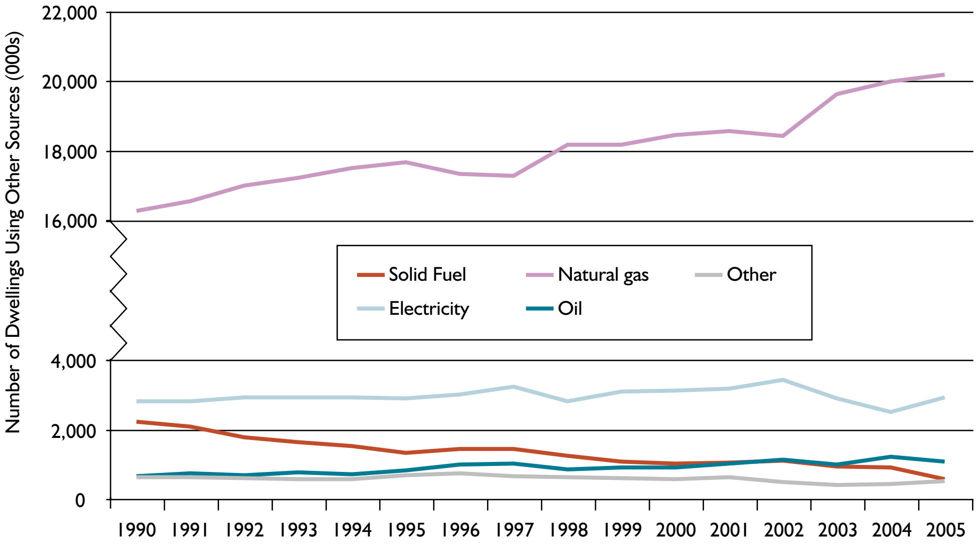

Figure 20: Heating in Great Britain by Fuel Type.
Source: BRE Domestic Energy Fact File 2007.[98] Chart: REF.

5.3. This figure has remained fairly stable over time, with the significant decreases (in 1997 to 1998 and 2002 to 2004) being explained by switching to natural gas, as the chart above shows.

5.4. However, when considering this group in terms of its exposure to risk of hardship as a result of increasing prices, it is important to note that fuel switching is not evenly distributed over the United Kingdom, due to lack of access to the gas grid, as can be seen in the following chart of the evolution of dwellings using electricity for heating. Scotland, for example, has experienced some movement away from electricity, and this is correlated with similar though larger movements in England, but the numbers using electricity are comparatively stable.

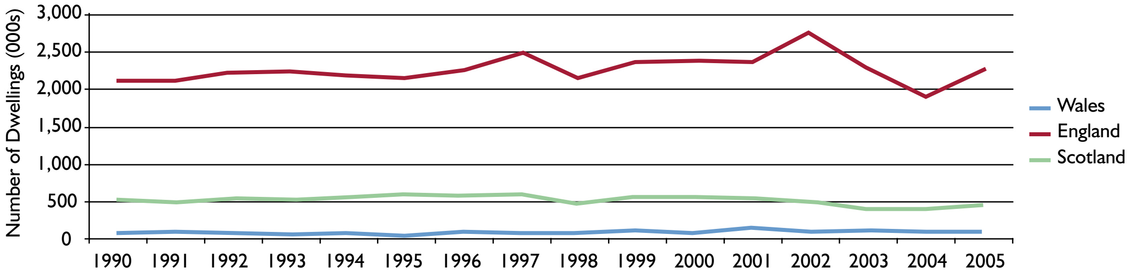

Figure 21: Dwellings Using Electricity for Heating 1990 to 2005.
Source: BRE Domestic Energy Fact File (2007).[99] Chart: REF.

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[98] http://www.bre.co.uk/filelibrary/pdf/rpts/countryfactfile2007.pdf

[99] http://www.bre.co.uk/filelibrary/pdf/rpts/countryfactfile2007.pdf

5.5. Indeed, a larger share of Scotland's total housing stock, around 20%, employs electricity for heating. (Pie charts displaying the numbers for each fuel in each country in 2005 are given in Appendix 2.)

5.6. It is therefore reasonable to infer that policy induced increases in electricity costs will have a disproportionate impact on risk of hardship in Scotland, even without taking into account lower ambient temperatures.

5.7. Furthermore, regional pricing differences give further cause for concern. EdF has recently started to publish such data, distributing printed texts to their customers, and making a pdf available online.[100]

5.8. This data is thought to be typical of the industry as a whole, and the following chart shows the regional variations in price in p/kWh at the standard rate across various parts of the United Kingdom:

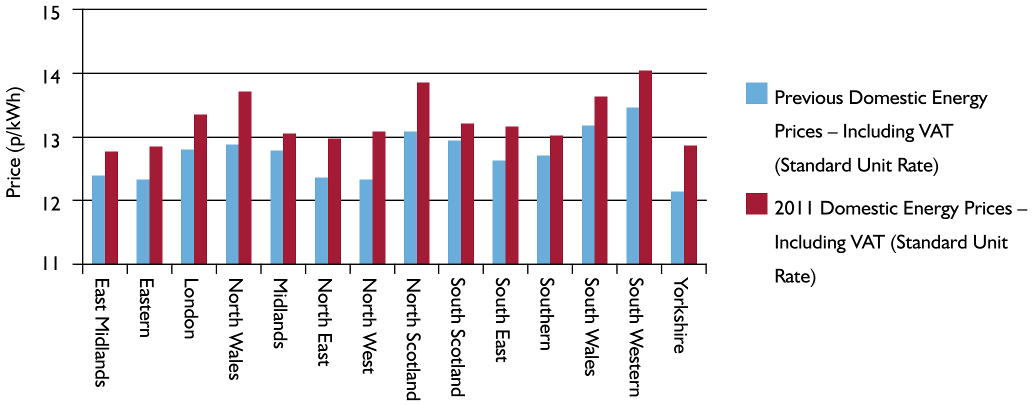

Figure 22: Comparison of the standard unit rate of electricity in p/kWh for domestic users across the regions showing the current (Nov. 2011) rates and the previous rates inclusive of VAT. Source: EdF.[101] Chart: REF.

5.9. These are significant variations in price and suggest that consumers using electric heating in Wales, North Scotland, and the South West, would all be more adversely affected by policy induced increases than households in other regions.

5.10. As a matter of physical fact there will be regional variations in the costs of delivering electricity to customers, but it is at least arguable that such costs should be socialized over the entire system, at least for domestic consumers, though the removal of this price signal might be macroeconomically disadvantageous to the United Kingdom overall.

5.11 The scale of the overall impacts of the Renewables Obligation, in particular, on domestic electricity prices and bills in 2020, can be appreciated from the total estimated system costs described above (see 3.3.9ff). The total RO costs as charted in Figure 6 imply an additional 11p/kWh of renewable electricity, consisting of subsidy and integration costs. The extra burden for those relying on electricity for heating can be estimated using the following assumptions:

- Annual electricity consumption of 8.7 MWhs for space heating.
- 30% notional renewable share of electricity supplied, in line with the national average target.

5.12. On such assumptions an electrically heated household might need to pay £320 per year extra on their space heating costs alone, not considering water heating and lighting, and before VAT and retail margins are taken into account.

5.13. These figures are necessarily imprecise and speculative, but are sufficient to indicate that those relying on electricity for their main source of heating, and indeed those who use it as an auxiliary source in

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[100] http://www2.savetodaysavetomorrow.com/documents/R77_02_09_v12_eco.pdf

[101] http://www2.savetodaysavetomorrow.com/documents/R77_02_09_v12_eco.pdf

extreme cold weather, will face considerably higher expenditure due to the effects of current policies.

5.14. This is particularly important since it is clear from the English Housing Survey that as many as 30% of all flats use electricity for heating, with the figure rising to as much as 50% of all purpose built, high rise, flats. Given that flats tend to be occupied by those on lower incomes this of special concern. Indeed, even though only 5% of houses employ electricity as the main source of heating, there is also reason for concern in those cases, as total heating need will be higher.

5.15. Examination of the trend of total numbers of households using electricity for heating reveals various other points of concern, as can be seen in the following chart:

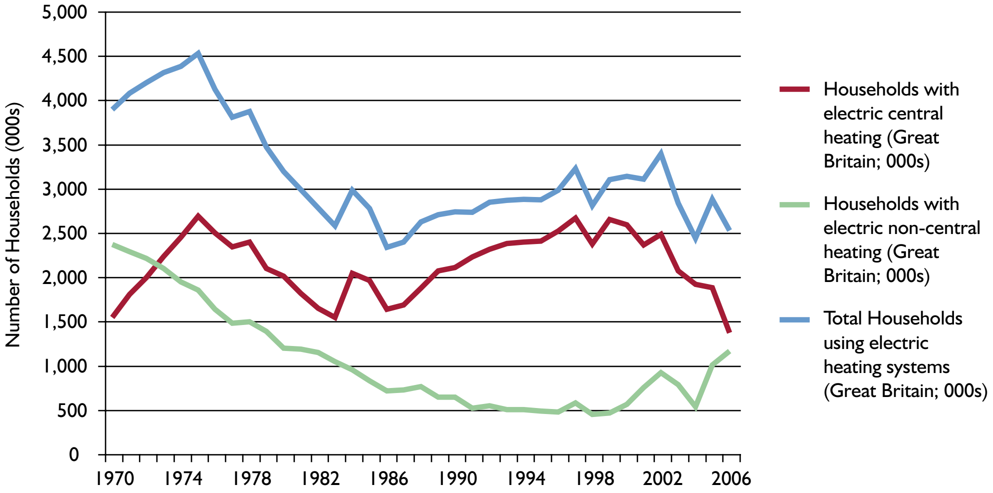

Figure 23: Households Using Electric Heating in Great Britain 1970 to 2006. Source: BRE Fact File 2008.[102] Chart: REF.

5.16. While the overall trend (blue line) shows a reduction in the use of electric heating from the 1970s to mid 1980s, numbers have not dropped much below 2.5 million since that time, suggesting that there are a core number of houses where alternatives to electricity are hard to find.

5.17. We also note that there is evidence of an increase in non-central electric heating. The causes of this are unclear, but Utley and Shorrock suggest increased installation in flats, which seems to us plausible.[103] Indeed, we are aware of anecdotal evidence that in certain urban conditions it is proving impossible to replace older gas boilers except by electric heating. For example, purpose built flats with internal flue systems which cannot be used by condensing boilers except at high cost may lack a suitable external wall in which to locate the vent. Since non-condensing boilers can no longer be fitted legally, such flats must move to electricity, and will be unable in most cases to adopt alternatives such as ground source or air source heat pumps. British Gas, for example, offers simple wall-mounted electric heating in such cases.

5.18. The scale of this unforeseen outcome of well-intentioned legislation relating to boilers is uncertain, but deserves investigation, particularly since it has the potential to cause a significant reversal of current trends away from electric heating.

5.19. Overall, we conclude that in terms of direct bill impacts those with heating systems entirely reliant on electricity should be regarded as vulnerable, and are suitable candidates for targeted intervention by government and NGOs working in this area.

5.20. A focused effort to locate households using electricity for heating, and, where possible, to encourage switching to gas might be effective in lowering risk of hardship. In areas where a gas supply is not

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[102] http://www.bre.co.uk/filelibrary/pdf/rpts/Fact_File_2008.pdf

[103] BRE, *Domestic Energy Fact File* (2008), 40. http://www.bre.co.uk/filelibrary/pdf/rpts/Fact_File_2008.pdf.

available, in Scotland and Northern Ireland for example, such households might be offered special assistance in adopting Renewable Heat Incentive (RHI) eligible technologies.

5.21. The Scottish Government has recently announced £1.9m in loans to support biomass district heating projects, an interesting development that may have some potential for reducing risk of hardship:

- Nine projects have been offered loans, including multi storey-housing in Cambuslang, an arts centre in Ullapool and a high school on Shetland.
- The projects will heat around 280 homes as well businesses, schools, swimming pools and community centres, while saving around 68,000 tonnes of carbon dioxide over 25 years.[104]

5.22. Nevertheless, there are over 400,000 homes in Scotland relying on electricity, and spontaneous rather than government-driven growth in the sector would be necessary to match the scale of the problem in the necessary timeframe.

5.23. Furthermore, as is apparent from the recently published Electricity Market Reform consultation, Government appears to have ambitions to greatly expand the use of electric heating in the United Kingdom as part of its ambition to decarbonize the economy.[105] Even if this is largely achieved through Ground-Source Heat Pumps with a high co-efficient of performance this would not appear to be clearly consistent with efforts to reduce risk of hardship to consumers, unless the costs of renewable electricity are expected to fall in the coming decade.

5.24. Overall, policy with regard to electric heating appears to be confused, and presents an area of extreme concern for those wishing to address increasing risk of hardship in relation to energy.

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[104] http://www.scotland.gov.uk/News/Releases/2011/11/04112708

[105] http://www.decc.gov.uk/assets/decc/11/policy-legislation/EMR/2176-emr-white-paper.pdf

6. Fuel Poverty and Energy Targets from a Scandinavian Perspective

6.0.1. The United Kingdom and the Scandinavian countries face similar problems in meeting the energy needs of the poorest members of society at a reasonable cost while also achieving EU climate change targets. However, there are important differences in the character of the problem, and in the response. The following review uses governmental data from the relevant authorities to shed light on these matters and draw attention to points of particular value for policy makers and analysts in the United Kingdom.

6.1. Space Heating Demands Compared

6.1.1. Curiously, and perhaps unexpectedly, total energy consumption per dwelling is similar for both United Kingdom housing and that of the Scandinavian countries, particularly when adjusted to an EU average temperature, as is illustrated in the following chart:

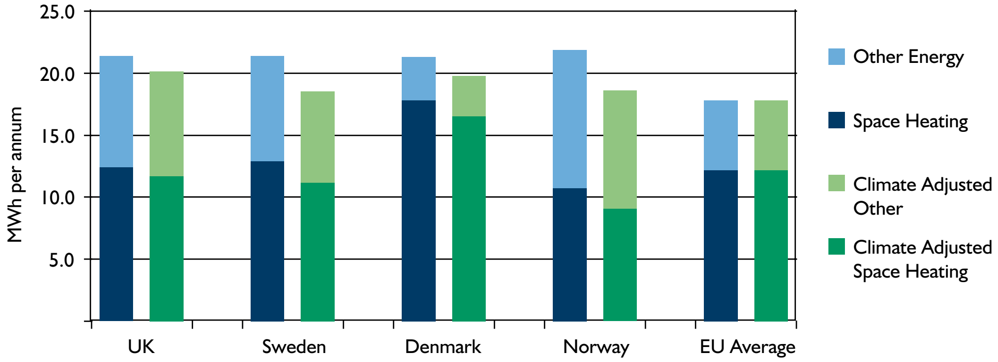

Figure 24: Energy Consumption per Dwelling per year in 2008 in the United Kingdom and the Scandinavian Countries. Data is Climate Adjusted Consumption scaled to EU Average climate on the basis of relative number of degree days. The total energy consumption used for space heating is indicated in the lower portion of the columns.
Source: Odyssee.[106] Chart: REF.

6.1.2. Of most relevance for considerations of fuel poverty is the relative energy consumption for domestic space heating in the four countries. However, although this data is monitored on behalf of the European Commission in order to enable evaluation of the efficacy of policy measures in Europe, the different countries report on a different basis, which can be confusing.

6.1.3. For example, the EU figures indicate that space heating accounts for approximately 60% of UK and Swedish domestic energy usage, and 50% for Norway, whereas the data for Denmark suggest more than 80% of domestic energy is used for space heating.

6.1.4. However, the Danish space heating figures include water heating,[107] whereas the figures for the UK do not. Given the similarity of the Swedish and Norwegian figures to those of the UK, we assume that these also do not include energy used for water heating, but we have no definite information on this point.

6.1.5. Because of this asymmetry in reporting, and in order to obtain a reasonable comparison of climate-adjusted domestic energy used by the Scandinavian countries and the UK, we have scaled the Danish space heating figure down by the ratio of 61/79 which is the relative share of domestic heating attributable to space heating alone, i.e. excluding the energy used for hot water, in the UK.

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[106] http://www.odyssee-indicators.org

[107] Personal communication from the Danish Energy Agency.

6.1.6. The following figure compares the Odyssee figures for space heating, expressed per square meter of floor space, in order to remove variability introduced by differences in dwelling sizes between the countries.

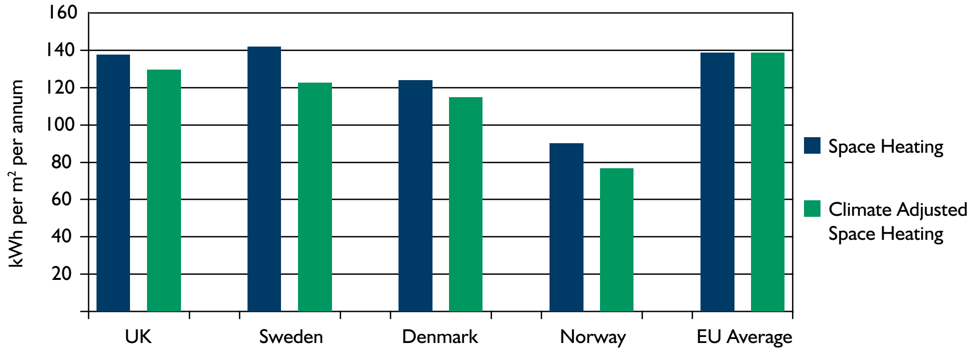

Figure 25: Comparison of UK and Scandinavian Energy Consumption for space heating per square meter per year in 2008. Climate Adjusted Consumption scaled to EU average climate on the basis of relative number of degree days. Note Danish figures scaled by REF using reasoning described in the text. Source: Odyssee.[108] Chart: REF.

6.1.7. It is evident that the Scandinavian countries are more efficient in their energy consumption for heating of dwellings with Sweden, Denmark, and Norway consuming 5%, 11%, and 41% less energy, respectively, than the UK.

6.1.8. It should also be noted that it is conceivable, though we have no data on this point, that even with the lower energy consumption, the Scandinavian countries enjoy warmer houses than the UK.

6.2. *Impacts of Fossil Fuel Price Volatility*

6.2.1. The volatility of fossil fuel costs has the most significant impact on domestic fuel bills, and study of this matter is greatly facilitated by the fact that specific CO_2 emissions per square metre (m^2) per dwelling per year are an excellent proxy for specific fossil fuel consumed in space heating.

6.2.2. The following chart displays data relating to kilogrammes of CO_2 emitted per m^2 of dwelling space.

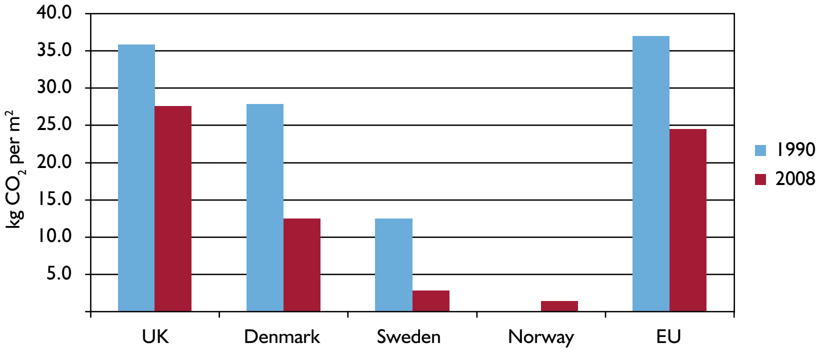

Figure 26: Comparison of CO_2 emissions (kg/m^2) from energy used in space heating during 1990 and 2008, scaled to the EU average climate. Source: European Environment Agency.[109] Chart: REF.

6.2.3. Although the heating season in Sweden, Denmark, and Norway is much longer than in the UK, the figure above demonstrates that the specific CO_2 emissions attributable to space heating in the UK in 2008 ranged from 2 to 20 times that in the Scandinavian countries. Nearly all

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[108] Source http://www.odyssee-indicators.org

[109] http://www.eea.europa.eu/data-and-maps/figures/co2-emissions-per-m²-for-1

space heating in Norway is from hydro-power generated electricity or log boilers, explaining the particularly low figures in that country. It is reasonable to infer that UK consumers are much more significantly exposed to fossil fuel price volatility. Scandinavian countries are buffered to some extent from this volatility for a variety of reasons.

6.2.4. Firstly, substantial improvements in the housing stock and heating systems were made prior to 1990, as is reflected in the better 1990 figures for Sweden and Denmark, compared with UK.

6.2.5. There has for some time been greater concern with energy security in those countries which, in contrast to the UK, have historically been net importers of coal, oil and, gas.[110] Indeed, memories of wartime privation might be said to be embedded into the national psyche.

6.2.6. The oil shock of 1973 precipitated an extended economic recession in Denmark and resulted in a national determination to avoid future oil dependency. Policy measures adopted around that time resulted in a substantial decrease in energy for space heating, with consumption falling from about 60 TWh in 1972 to 44 TWh in 1997, a reduction of 25%.[111]

6.2.7. It is important to note that this policy did not necessarily imply a move to renewables, with switching from oil to alternative fossil fuels being highly significant. Indeed, in 1973 all the city-based thermal power plants in Denmark were oil-fired, but by 1984 these had been converted to coal-firing. Denmark imports all its coal, and in 2009 import levels expressed per capita of population were approximately 2, 6 and 8 times those of the UK, Sweden and Norway respectively.[112]

6.2.8. The continued use of coal is undoubtedly one of the reasons why CO_2 emissions in Denmark still exceed its 2012 Kyoto target, whereas the UK, Sweden, and Norway have met their Kyoto targets.[113]

6.2.9. However, the Danish programme of switching from oil- to coal-fired generators focused on the construction of plant with world-class thermal efficiency and model cleanliness, the latter point being particularly important in view of their near urban location.

6.2.10. Denmark's consumer-owned, regionally-organized, electricity industry was created early in the last century, and from the outset the thermal power plants have been developed to run as Combined Heat and Power (CHP) units delivering district heating to its citizens as well as electricity. The district heating provides both space heating and hot water (which is why it is difficult for the two factors to be separated out in statistical reporting of domestic energy usage).

6.2.11. All the base-load power plants in Denmark are over 42% efficient in condensing mode – (i.e. when delivering no district heating in high summer) – and up to 93% fuel efficient in full CHP mode. Denmark still boasts several coal-fired plants that are the most efficient in the world. Nordjyllandværket near Aalborg, for example, is 48% efficient in condensing mode, and as a consequence of this, only a small fraction of the primary energy used is lost to the environment in winter.

6.2.12. In contrast to Denmark, the UK's coal fired power plants are about forty years old on average, and they are at best only capable of about 37% efficiency when in condensing mode. None of

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[110] Both Denmark and Norway have recently become hydrocarbon producers and exporters. But both nations have more conservative views on the exploitation of their resources than the UK and have put in place policies that reward and maximize field extraction. In particular, Norway has built a giant "rainy day" sovereign wealth fund that anticipates its eventual return to becoming a hydrocarbon importer.

[111] http://www.eci.ox.ac.uk/research/energy/downloads/countrypictures/cp_denmark.pdf

[112] Total coal import levels have been taken from the International Energy Statistics collected by the US Energy Information Administration. See http://www.eia.gov/coal. Population data from: http://www.indexmundi.com.

[113] Tracking Progress Towards Kyoto and 2020 Targets in Europe, 2010, European Environment Agency. http://www.eea.europa.eu/publications/progress-towards-kyoto Also see http://www.energy.eu/ for summary chart.

these plants delivers district heating, so after losses in transmission and distribution, 63% of the primary energy used in the coal (and oil) electricity generating plants is dissipated to the environment. Although the UK's newer, gas-fired Combined Cycle Gas Turbines (CCGTs) are more efficient, nonetheless 40–50% of the primary energy consumed in gas-fired CCGTs is dissipated into the environment.

6.2.13. Putting these figures into context, waste heat from the UK coal and gas electricity generating stations is equivalent to about a quarter of the UK's entire domestic heating requirement.[114]

6.2.14. Even in the smaller towns and villages, district heating has been a feature of the Danish power industry since 1990, with some six hundred decentralized district heating plants, most of these being CHP plants, currently in operation. Those that are heat-only, as distinct from CHP plants, burn biomass, much grown in Denmark itself.

6.2.15. Nearly all combustible waste is incinerated in regional waste to energy plants that also distribute the heat thus generated to the district heating systems. Approximately 1.5 million households, or 60% of the total, are connected to district heating networks.[115]

6.2.16. Consequently, Danish domestic heating is marked by a high degree of fuel diversity, as is illustrated in the following figure:

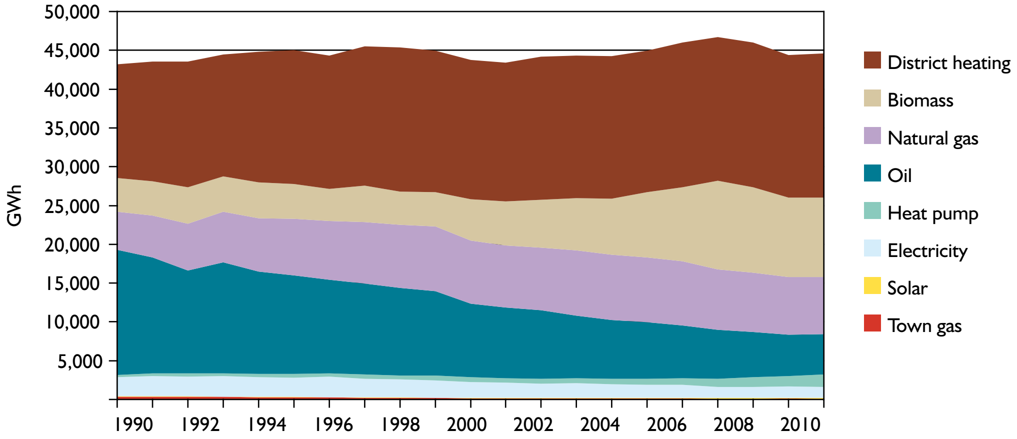

Figure 27: Fuels used for space and water heating in Danish households.
Source: Danish Energy Agency. Chart: REF.

6.2.17. It is instructive to compare the 2010 figures for Danish and UK domestic heating fuels, an exercise that shows how exposed the UK is to fossil fuel, notably gas, price volatility (Figure 28).

6.2.18. Natural gas was only introduced in Denmark relatively recently, starting in the 1980s, and subsequently use of this fuel in domestic heating increased to a peak around 2003, after which time it has declined.

6.2.19. In 1997 approximately 6% of all Danish households were electrically heated. This proportion has fallen owing in part to policies specifically designed to prevent an increase in the number of electrically heated dwellings in Denmark, and to facilitate the conversion of existing electrically heated dwellings to district heating or natural gas.

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[114] For electricity generating stations output see Energy Trends 5.1 Fuel Used in Electricity Generated and Supplied, DECC and for domestic energy used for heating, refer to DECC Energy Consumption in the UK. http://www.decc.gov.uk/en/content/cms/statistics/energy_stats/source/electricity/electricity.aspx http://www.decc.gov.uk/en/content/cms/statistics/publications/ecuk/ecuk.aspx

[115] Danish District Heating Association: http://www.danskfjernvarme.dk/in%20english.aspx.

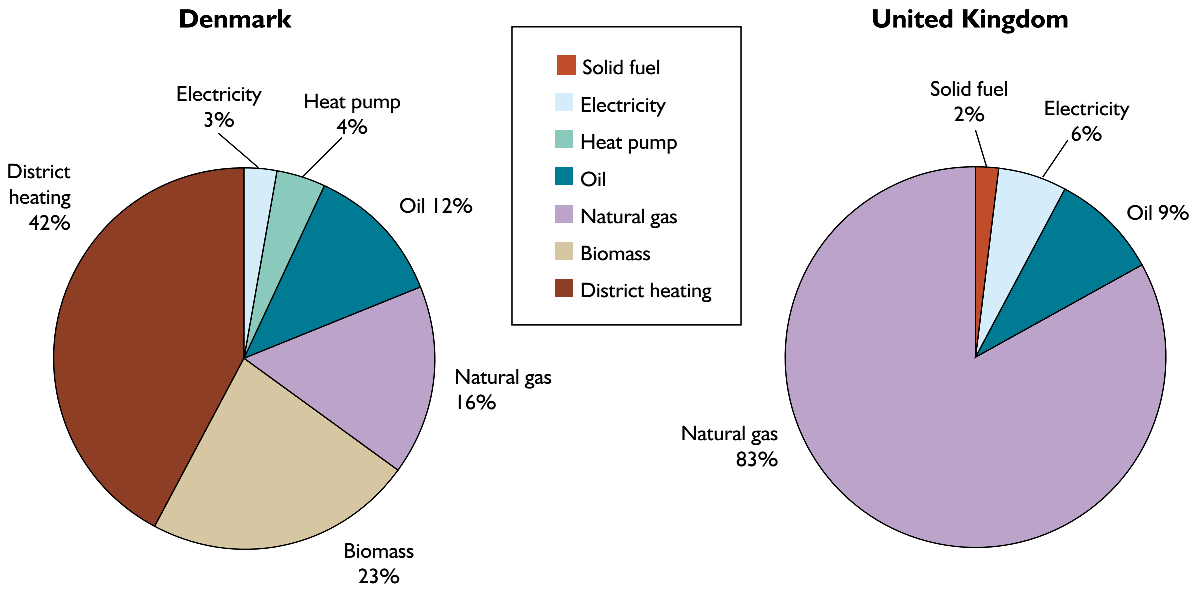

Figure 28: Fuels used for space and water heating in Denmark (left) and the UK (right) in 2010. Source: Danish Energy Agency and DECC.[116] Chart: REF.

6.2.20. However, the use of electricity for heating is projected to increase again, as it is planned to use Denmark's significant wind power surpluses in this way as an alternative to constraint or export at potentially disadvantageous prices. Whether this can be achieved without economic disadvantage to consumers remains to be seen, but it may well be preferable to the current state of affairs.

6.2.21. An exception to the generally benign domestic heat situation in Denmark is the approximately 20,000 families receiving heat from gas-fired CHPs (barmarkværker – or "open field plants"). These were built during the 1990s to encourage a switch away from oil, requiring a whole village to participate in the capital and operating costs of these small stations. Unfortunately, these have never been economic, due to the high, one-off, capital cost of paying for a power station and district heating in one step.[117] This experience should be salutary for energy co-operatives in the UK.

6.2.22. In summary, the evolution of energy policy and actual use in Denmark has been a long term project. The strategy enjoys cross party support and, certainly in heating, reduces the exposure of households to global energy price volatility, though at a cost.

6.3. Energy Taxes

6.3.1. In Denmark, electricity has for some time been treated as if it were a luxury item and subject to high taxes as a consequence. The following chart (Figure 29) shows the relative domestic retail cost of electricity across a range of European countries. Despite having costs at around the median level for Europe, Denmark has the highest domestic electricity price of all the EU member countries because of its electricity taxes.

6.3.2. These include taxes on energy consumption, distribution, CO_2, and a tax to finance the Danish equivalent of the Energy Savings Trust, as well as 20% VAT.

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[116] UK data is available from the DECC website – see Overall Data tables at the following URL: http://www.decc.gov.uk/en/content/cms/statistics/publications/ecuk/ecuk.aspx.

[117] Frede Vestergaard, energy journalist, personal communication.

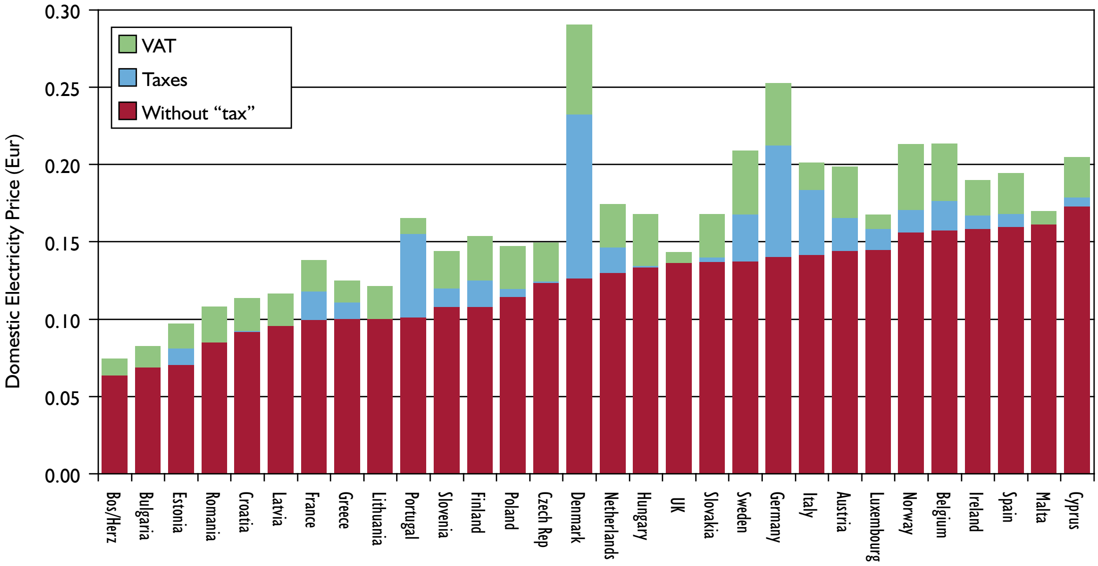

Figure 29: Prices of domestic electricity for first half 2011 and consumption levels of less than 3,500 kWh per annum. Note that the price without "tax" may include environmental levies, such as the United Kingdom's Renewables Obligation.
Source: Eurostat. Chart: REF.

6.3.3. Furthermore, what is not included in the list of taxes and is rather more difficult to quantify because it is instead included in the electricity price, is the Danish Public Service Obligation (PSO), a levy used to subsidize renewable energy generation and research and development into green energy issues.[118] This is the Danish equivalent of the UK's Renewables Obligation, Feed-in-Tariff, and other environmental policies that are similarly included in the price of UK electricity.

6.3.4. The PSO for 2009 added DKK 3.5 billion to bills[119] and thus, given the 2009 final electricity consumption of 31,582 GWh,[120] amounted to approximately DKK 0.1108 per kWh. The following chart (Figure 30) shows that this levy amounts to about 5% of the final electricity cost, and also shows that taxes on electricity consumed by domestic households comprised nearly 60% of the retail price.

6.3.5. Danish electricity was originally taxed primarily as a revenue raising measure, although a secondary aim was to incentivize replacement of oil with other energy sources.[121] In later years, taxes have been added to electricity to meet climate change and renewable energy targets. In spite of ten years of a centre-conservative government, there has been no reform of energy pricing.

6.3.6. These taxes are regressive in their effects, which is to say that the burden of environmental and other taxes on electricity weighs disproportionately heavily on those with low incomes. However, a portion of this very high overall tax take from household consumers is used to subsidize poorer consumers at the expense of wealthier consumers.

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[118] Danish Energy Statistics 2009, Danish Energy Agency.

[119] Danish Energy Statistics 2009, Danish Energy Agency.

[120] See Tables 2009 from Danish Energy Agency http://www.ens.dk/en-US/Info/FactsAndFigures/Energy_statistics_and_indicators/Annual%20Statistics/Sider/Forside.aspx

[121] See UCD Dublin: Economic Instruments in Environmental Policy. http://www.economicinstruments.com/index.php/climate-change/article/120-

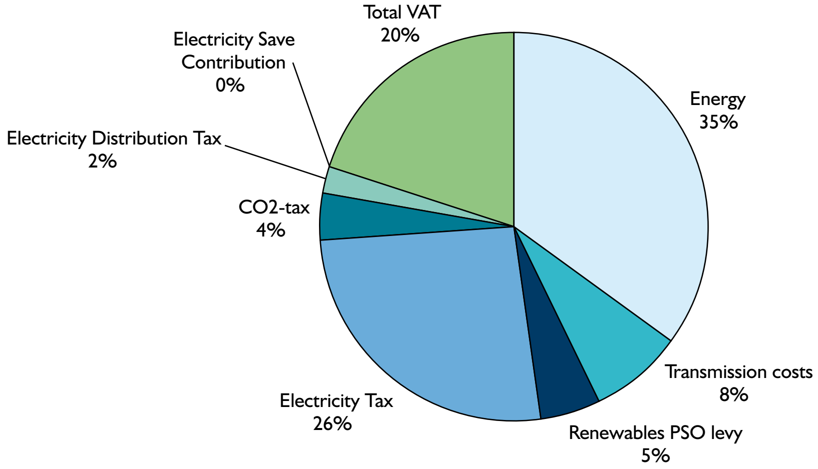

Figure 30: Relative proportions of the Danish domestic retail electricity price 2009. Source: Danish Energy Agency. Chart: REF.

6.3.7. High taxes on the consumption of all forms of energy are a feature of Scandinavian energy policy, even in Norway, and the resulting high prices are essentially a convenient means of redistributing "comfort" from wealthier to poorer consumers through the mechanism of the social benefits system.

6.3.8. Consequently, fuel poverty is not an issue in Scandinavia. At the beginning of 2011, the GDP per capita of Norway was US$54,000 per year, while that of Sweden stood at US$39,100, and that of Denmark US$36,600. The United Kingdom, though a much larger economy than any, has an even lower GDP per head than Denmark, $34,800.[122] With national per head wealth at relatively high levels, and for other reasons, it has been possible to tackle economic hardship in the Scandinavian countries through the social budget, and, importantly, the inability to afford adequate energy services is not regarded as a problem to be solved by the energy sector.

6.3.9. Norway is a very special case. 99% of its electricity is normally derived from hydropower generators the capital costs of which were recovered several decades back, and the country exhibits a large trade surplus due almost entirely to hydrocarbon exports. Consequently, it is an extremely wealthy state with very secure social services for those unfortunate few who are poor. For those, mostly country dwellers, who do not use electricity for heating, the country has a vast forest, and woodstoves are consequently much favoured.

6.3.10. Furthermore, it should be noted that the populations of Scandinavia exhibit a more even distribution of incomes than in the UK, with high personal and energy taxes being used to redistribute wealth, making severe poverty very rare. The Gini Coefficient measures how evenly a country's wealth is distributed across its population: a Gini Coefficient of 0 represents perfect equality with all households having an equal share of the available income. A Gini index of 100 implies complete inequality.[123]

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[122] http://www.indexmundi.com/g/r.aspx?v=67

[123] World Bank http://data.worldbank.org/indicator/SI.POV.GINI

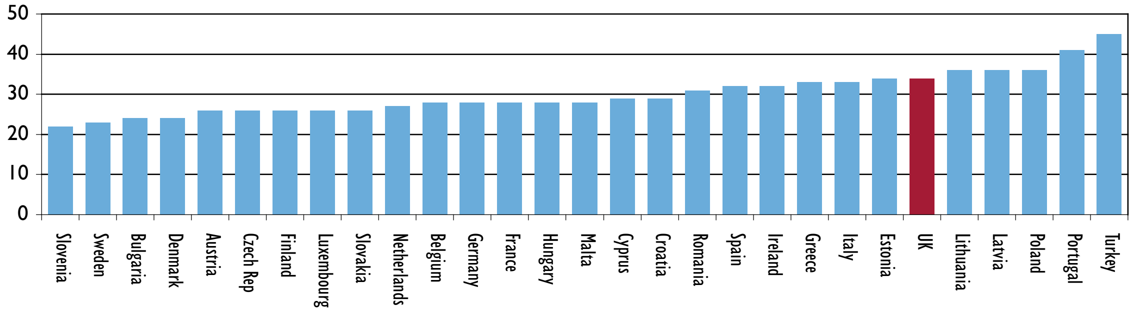

Figure 31: Gini Coefficient for European countries showing relative wealth distribution. Source: Eurofound.[124] Chart: REF.

6.3.11. As can be seen in the Gini Coefficient chart, there is a considerable difference in wealth distribution with Sweden and Denmark displaying a less unequal income distribution than the UK. In Denmark and Sweden people with an income that is less than 60% percent of median income receive social transfer payments for many of the basic necessities of life such as accommodation, food, and energy, where assistance is considered appropriate.

6.4. Conclusions

6.4.1. The Scandinavian countries are well ahead of the UK in improving their housing stock, and the quality of Scandinavian housing stock is not only currently high but continues to improve.

6.4.2. Domestic heating is supported by a diverse and/or indigenous fuel supply, buffering householders against some of the impacts of world fossil fuel price volatility.

6.4.3. Taxes on electricity, particularly in Denmark, are very high and bear disproportionately on the poorer members of society. However, comparatively generous social policies and greater median incomes ensure that cases of actual hardship are very rare, and risk of hardship is reduced in the lower income deciles.

6.4.4. A particularly interesting and significant difference between Denmark and the UK is the substantial use of district heating, particularly from CHP-capable base load power plants. District heating currently contributes only approximately 2% of the heat supply in the UK compared with 42% in Denmark.

6.4.5. In 2009 DECC commissioned research that determined that district heating could feasibly provide up to 14% of the heat demand of UK buildings.[125] While acknowledging that the cost of installing a network of hot water pipes is high, the research report noted that some combinations of fuel sources and building types make particular schemes feasible. These are schemes that use waste heat from conveniently sited power stations, schemes which replace electric heating systems and schemes which supply commercial premises and high rise flats in high heat load areas.

6.4.6. In the light of the Danish experience, we suggest that DECC revisit the recommendations in that report to see if there is indeed potential for increasing the use of district heating in the UK.

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[124] See: www.eurofound.europa.eu.

[125] The Potential and Costs of District Heating Networks, April 2009. DECC by Pöyry, Faber Maunsell, Aecom.

7. Energy Efficiency and UK Dwellings

7.1. European Targets for Energy Efficiency

7.1.1. Improving energy efficiency is one of the three so-called 20-20-20 EU targets for 2020. Specifically, efficiency measures are sought to achieve a reduction in primary energy consumption of 20% compared with projected levels that are calculated assuming Business As Usual.

7.1.2. As a target, this has obvious drawbacks, including the fact that primary energy consumption in 2020 is unknown and current projections are being made against a backdrop of particularly unstable economic conditions.

7.1.3. While the other two branches of the energy targets (the renewables and greenhouse gas emission targets) are mandatory, the EU energy efficiency target is an aspiration only.

7.1.4. Moreover, the EU is not on track to meet this target, with the latest data indicating efficiency savings of only 9% being likely by 2020.[126]

7.1.5. The energy savings aspiration is covered by two existing EU Directives.[127] However, in June 2011, the EU published a draft Energy Efficiency Directive which, if adopted, will supersede the previous legislation and has the aim of increasing the uptake of efficiency measures and thus increasing the likelihood of meeting the 20% efficiency target by 2020.[128]

7.1.6. The new directive would still not have a mandatory target, but instead would have mandatory efficiency measures that EU countries must adopt. Examples of the proposed measures which have an effect on domestic energy consumers include:

- The legal requirement that energy suppliers save 1.5% by volume of their energy sales per annum by improving the efficiency of their customer's heating, installing double glazing or household insulation.
- Improved access to metered energy data for customers.

7.2. Domestic Dwellings

7.2.1. To grasp the impact of energy efficiency measures in the context of fuel poverty, and thus dwellings, and the significance of the 20% energy savings target, it is necessary to understand the quantitative context of domestic energy usage.

7.2.2. Domestic users accounted for 564 TWh, i.e. approximately one third of the UK's Final Energy Consumption (FEC) in 2010, as is illustrated in Figure 32.

7.2.3. Domestic household energy can be broken down into the various services. Unsurprisingly, nearly 80% of a household's energy is used for space heating and hot water (Figure 33).

7.2.4. Combining the data in the figures below we can see that nearly a quarter of the UK's final energy consumption is used on domestic space heating and heating domestic hot water. Significant energy savings in this sector would clearly be of major benefit at a national level but also for individual householders needing to reduce energy expenditure.

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[126] See the MEMO/11/440 26 June 2011 accompanying the Commission's new Energy Efficiency Directive. http://europa.eu/rapid/pressReleasesAction.do?reference=MEMO/11/440&format=HTML&aged=0&language=en&guiLanguage=en

[127] These two directives are the Cogeneration Directive (2004/8/EC, CHP Directive) and the Energy Services Directive (2006/32/EC, ESD)

[128] http://ec.europa.eu/energy/efficiency/eed/eed_en.htm. http://www.decc.gov.uk/en/content/cms/consultations/eceed/eceed.aspx

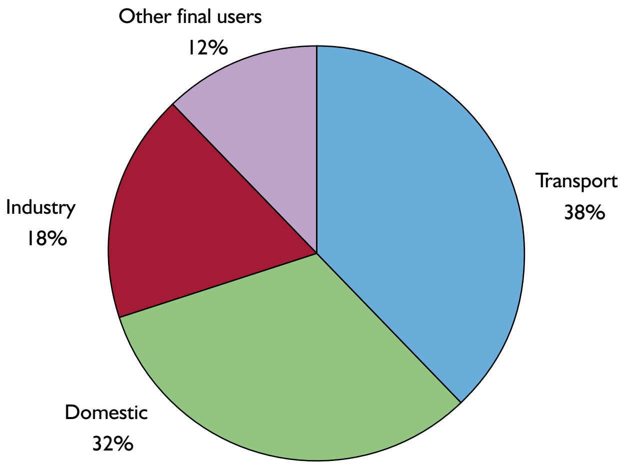

Figure 32: Proportion of 2010 Final Energy Consumption by end user in 2010
Source: DECC.[129] Chart: REF.

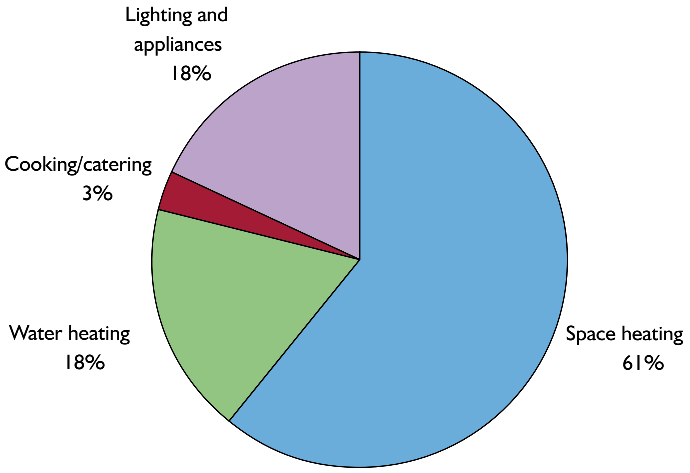

Figure 33: Share of domestic energy by end use.
Source: DECC.[130] Chart: REF.

7.3. Targets Translated to Household Level

7.3.1. In order to assess the ultimate potential for domestic energy savings, it is useful to consider the domestic energy consumption on a per household basis. The latest report from DECC on the Energy consumption in the UK[131] gives an average figure of 21.20 MWh per household for the 26.6 million households in the UK.

7.3.2. The average floor area of UK houses is 91m^2, and from this we can estimate a value for the energy usage for an average UK dwelling, namely 233 kWh/m^2/annum for total energy demand, and for space heating alone 142 kWh/m^2/annum. Figures grounded in this metric can be compared with the best insulated of housing stock, namely the PassivHaus.

7.3.3. PassivHaus refers to the German concept of building ultra low energy dwellings through rigorous attention to minimizing heat loss from a dwelling. It requires highly insulated walls, roof, floor, triple glazed windows, excellent air tightness and usually mechanical ventilation with

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[129] http://www.decc.gov.uk/en/content/cms/statistics/publications/ecuk/ecuk.aspx

[130] http://www.decc.gov.uk/en/content/cms/statistics/publications/ecuk/ecuk.aspx

[131] Numbers taken from the domestic data tables dated 15 Sept 2011 from the DECC report on the Energy Consumption in the UK. http://www.decc.gov.uk/en/content/cms/statistics/publications/ecuk/ecuk.aspx

heat recovery. A high energy performance standard is required to be met in order to receive PassivHaus certification.[132]

7.3.4. The PassivHaus energy performance target figures require a dwelling to achieve primary energy demand as low as 120 kWh/m²/annum and specific space heating demands of as low as 15 kWh/m²/annum.

7.3.5. Building a new house to the PassivHaus standards is exacting enough but refurbishing an existing property to meet them can involve major work and costs which would be prohibitive for most. There is an alternative standard for refurbishment work which keeps the target figure of 120 kWh/m²/annum for primary energy but has a slightly less demanding space heating target of 25 kWh/m²/annum.

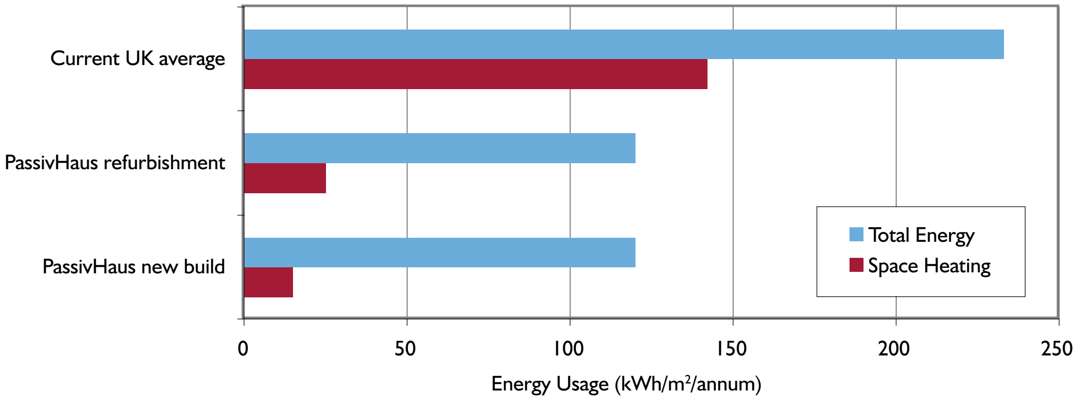

Figure 34: Comparison of UK average energy usage per dwelling with the high building energy efficiencies met by the PassivHaus standard.
Source: PassivHaus. Chart: REF.

7.3.6. These figures demonstrate that very significant reductions in energy use for dwellings are possible, although the cost of achieving these levels is usually too high to be a realistic proposition for most refurbishment. However, it is useful to establish an indication of what is possible in terms of energy efficiencies per dwelling.

7.3.7. Furthermore, the appeal of the PassivHaus targets is their simplicity and relevance, since the energy consumption of a dwelling can be readily approximated from the electricity and gas bills. This contrasts with targets that are based on CO_2 emissions, which are more remote from the energy data with which the layperson has some day-to-day familiarity.

7.4. Losses and Gains in Providing Energy to a Dwelling

7.4.1. It is also useful to understand the losses and gains in providing energy to an average UK house. Figure 35 has been calculated and redrawn from Uttley and Shorrock's 2008 *Domestic Energy Fact File*, and gives an indication of the energy flows for an average house based on 2006 figures.[133]

7.4.2. The first and second columns in the figure show how energy generated at power stations and destined for the average house differs between the primary energy stage and energy as actually delivered, reflecting energy conversion losses in the power stations themselves, plus the energy lost in the transmission and distribution networks.

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[132] http://www.passivhaus.org.uk

[133] See Figure 36 *Domestic Energy Fact File* 2008 Utley & Shorrock

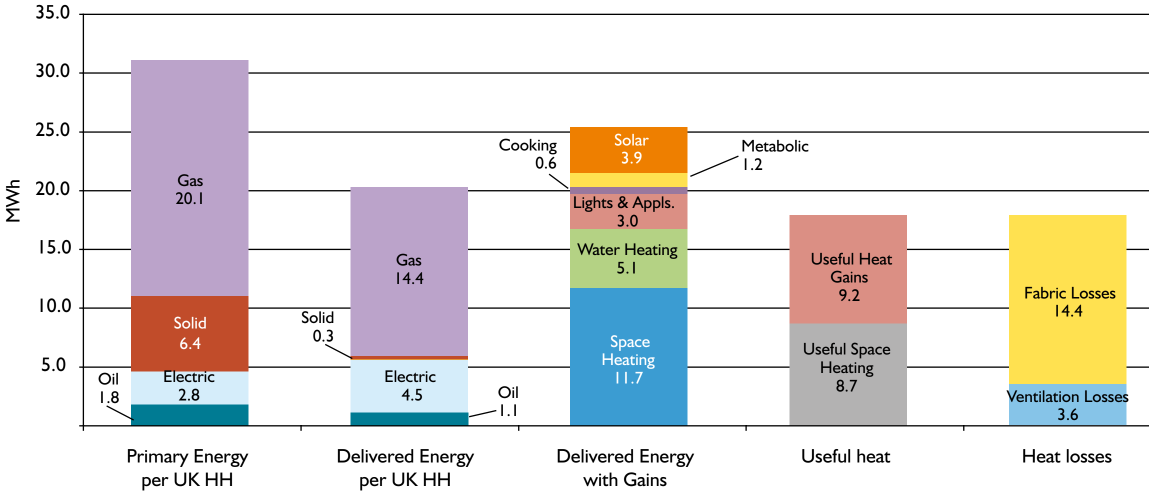

Figure 35: Average Household Energy Balance, 2006 in the United Kingdom.
Source: Uttley & Shorrock, *Domestic Energy Fact File* (2008). Chart redrawn by REF.

7.4.3. The third column shows the delivered energy plus extra energy gained by solar heat and also, metabolic gains – essentially body heat from the occupants of the house. The other items in the third column show the delivered energy used for space heating, water heating, lighting and appliances, and cooking.

7.4.4. The fourth column shows that the actual heat is less than that supplied, since the useful portion of space heating is reduced as a result of the efficiency of the particular appliance used for space heating. Clearly this varies depending on fuel source and age of the conversion device, for example the boiler. A modern condensing gas-fired boiler has a theoretical efficiency of 90% or more, whereas an older, non-condensing, device could be as low as 70% efficient. A gas fire may be 50% efficient, an electric storage heater 90%, electric heating around 100%. An average of 74% is assumed in the figure.

7.4.5. The top portion of the fourth column gives the useful portion of the incidental heat gains from cooking, lighting, hot water, and so on, and shows that about one third of these incidental heat gains are lost. This can be from hot water flowing out into the drains, cooking heat extracted to the outside, and windows being opened in summer deliberately to dissipate excess incidental heat.

7.4.6. The fifth column shows how the average house loses heat, with approximately 20% lost by ventilation and the rest through the fabric of the building itself.

7.4.7. Utley and Shorrock's chart is immensely useful for gaining insight as to where energy savings can be made. For instance:

- Maximizing solar gains shown in the third column reduces the need for additional space heating.
- Increasing the efficiency of space heating appliances increases the proportion of *useful* space heating.
- Minimizing fabric and ventilation losses through improved insulation reduces the total amount of heat required in the house.
- Reducing heat losses by heat recovery would increase the proportion of useful incidental heat gains and reduce the need for space heating.

7.5. Cost of Heating

7.5.1. From the figure above we could make the assumption that the average house requires 8.7 MWh of space heating per annum. The cost of providing that heat will vary depending on the fuel used and the efficiency of the appliance used to burn the fuel. The following table shows that to obtain that fixed amount of heat, the cost could range from £401 per annum for gas as fuel for a highly efficient condensing boiler to £1,121 per annum for using electricity.

Table 8: Domestic Space Heating Fuel Use, Efficiency and Cost

Fuel	*Efficiency (%)*	*MWh used*	*p/kWh*[134]	*Total Cost (£)*	*Dwellings (%)*[135]
Gas	90–70	9.7–12.4	4.15	401–516	85
Oil[136]	90–70	9.7–12.4	6.1	590–758	4
Electricity	100	8.7	12.89	1,121	10

7.5.2. This simultaneously demonstrates the significant costs faced by those households without access to the gas network, and the potential savings that could be achieved by switching household heating from electric or oil to gas.

7.6. Energy Efficiency of Housing Case Studies

7.6.1. There is a solid and increasing body of publications describing a range of case studies that investigate the retrofitting of energy saving measures into existing housing stock.

7.6.2. The majority of houses in the UK were built before energy efficiency standards were given legal status in building regulations. Indeed, the energy efficiency requirements in the building regulations have become increasingly stringent since the initial introduction in 1965 of limits on how much energy could be lost through walls and roofs. Revisions to make the building regulations more exacting occurred in successive decades and the most recent revision is in "Part L: Conservation of Fuel and Power", which became mandatory in 2010.

7.6.3. However, as can been seen from the figure below, approximately 60% of the housing stock predates the 1965 introduction of the simplest of building energy savings legislation. Clearly refurbishment of existing properties rather than demolition and rebuilding to improved standards is necessarily the way forward.

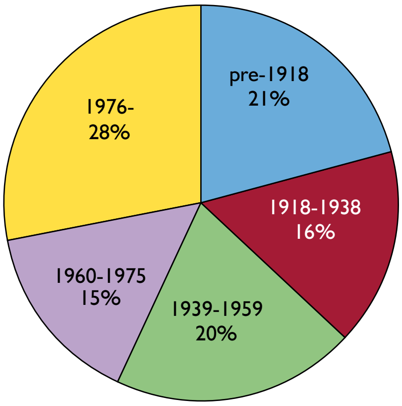

Figure 36: Number of dwellings in Great Britain, classified by year built.
Source: DECC.[137] Chart: REF.

7.6.4. In the following section we describe the Standard Assessment Procedure (SAP) index, which is a key metric used by all of the studies when discussing the energy efficiency of buildings, and

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[134] http://www.decc.gov.uk/en/content/cms/statistics/energy_stats/prices/prices.aspx#domestic

[135] % of dwellings using each main fuel type is sourced from Summary Statistics Table SST6.1 2009. English Housing Survey. http://www.communities.gov.uk/housing/housingresearch/housingsurveys/englishhousingsurvey/ehstables/

[136] Oil price of 61p/litre inclusive of VAT taken from http://www.boilerjuice.com/heatingOilPrices.php. Also assumed is the conversion of 10 kWh per litre.

[137] http://www.decc.gov.uk/assets/decc/11/stats/climate-change/3224-great-britains-housing-energy-fact-file-2011.pdf

then summarize five of the case studies available in the literature, and show that several of the case studies come to similar conclusions.

7.7. SAP: Standard Assessment Procedure

7.7.1. The Standard Assessment Procedure (SAP) is a theoretical calculation of a building's energy efficiency. It is used by the Government for assessing energy used by buildings and as a means of determining UK's compliance with the European Energy Performance of Buildings Directive. It underpins several energy policy initiatives.

7.7.2. The SAP rating of a dwelling is a mandatory part of determining compliance with Part L of the building regulations.

7.7.3. The SAP rating scale runs from 1 to 100, where the higher the number the more energy efficient the building and the lower the costs for heating, lighting and ventilating the building.

7.7.4. A SAP rating of 100 would indicate that the energy efficiency is so high that the cost of providing energy for the dwelling is zero. It is possible for a SAP rating to rise above 100 if a dwelling exports energy: for example, if it generates electricity via solar PV or other microgeneration. The SAP rating is independent of floor area.

7.7.5. It is important to understand that houses with the same SAP rating will not necessarily use the same amount of energy or therefore cost the same amount to heat. This is neatly illustrated by data gathered during field trials of micro-CHP units carried out by the Carbon Trust. Table 13 of the interim report[138] compares twelve new but nearly identical properties from a single housing development. All of the properties had a pre-build projected SAP heat loss coefficient of 114 W/°C. However, the actual measured heat loss coefficients ranged from 96 to 178 W/°C and the actual annual gas use varied from 7.45 MWh p.a. to 15.6 MWh p.a.

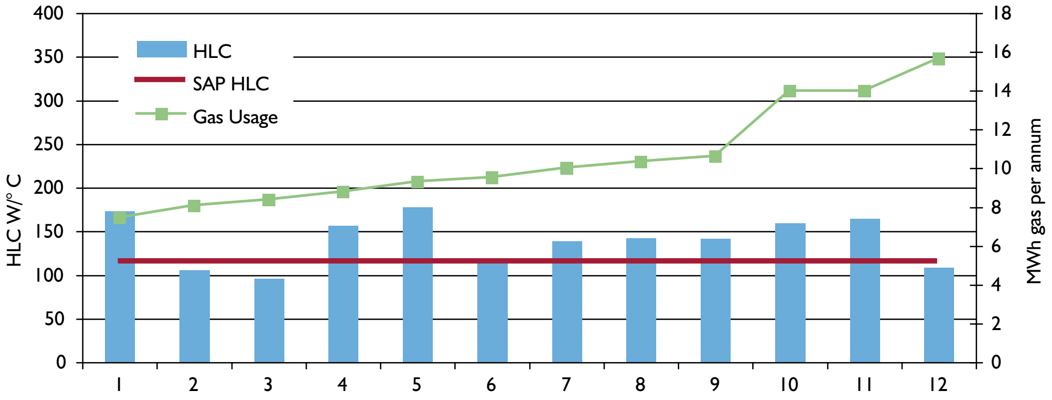

Figure 37: Comparison of predicted SAP and measured heat loss coefficients (HLC) for 12 nearly identical new-build properties and the annual gas use.
Source: Carbon Trust.[139] Chart: REF.

7.7.6. Thus we see that actual energy usage for very similar houses varies significantly and depends on the actual circumstances of the occupants, with an enormous range of possible outcomes. For example, those in full time work are usually out of the house during the day, but may work nightshifts; retired persons may or may not choose to heat the house during the day. Invalids and the disabled may require more warmth than able-bodied occupants. Some residents may tend to leave windows open or fail to make effective use of heating controls.

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[138] See table 13 in Micro-CHP Accelerator, Interim Report November, 2007. Carbon Trust. http://www.carbontrust.co.uk/publications/pages/publicationdetail.aspx?id=CTC726

[139] See table 13 as above.

7.7.7. The key point is that a theoretically-derived SAP rating for a dwelling is only an estimate based on a model, and should be treated with caution. (The implications for the current definition of fuel poverty, in which SAP rating is an important element, should be sufficiently obvious.)

7.8. Case Study 1: Warm Front – Hong & Oreszczyn

7.8.1. An extensive series of studies on the outcomes of the Government's Warm Front interventions have been carried out by a team of academics led by Professor Tadj Oreszczyn at University College London. These studies have revealed some unexpected outcomes of the policy that demonstrate the importance of empirical measurements to establish the efficacy of policy.

7.8.2. Warm Front is a Government-funded, social policy programme launched in June 2000, and initially administered by DEFRA, though now under the aegis of DECC. Warm Front's aim is to alleviate fuel poverty by providing grants for:

- Cavity wall insulation
- Loft insulation
- Draught proofing
- Gas wall convector heaters or gas central heating.

7.8.3. Warm Front is designed to help the vulnerable and fuel poor in privately owned or privately rented households. Identifying these households has proved problematic, with the original criteria requiring recipients to be in receipt of particular benefits and in particular age bands for the very young and the elderly.

7.8.4. The identification of appropriate recipients for the Warm Front interventions was criticized in a report on the scheme by the National Audit Office (NAO) in 2009. This report noted that some of the funding had gone to households which were not fuel poor or were already relatively energy efficient. Nearly 75% of the vulnerable households eligible for the scheme were not fuel poor.[140]

7.8.5. DECC re-launched the scheme in 2011 with amendments to the criteria for eligibility in order to improve targeting.[141]

7.8.6. The NAO report also commented on the results of SAP modelling that had been used to rate the houses before and after Warm Front interventions, noting that while modelling shows that the SAP index has improved overall, the averages tend to hide some less impressive results. For example, although the percentage of houses with the lowest SAP rating of 10 or lower is reduced after the Warm Front interventions, 4% of properties remain in that lowest efficiency band even after receiving assistance.

7.8.7. This could be explained by the fact that some of the Warm Front money had gone on minimal measures such as supplying households with two low-energy light bulbs, a measure which would not have any significant effect on the fuel poverty status of the household. Between June 2005 and March 2008, 24% of assisted households received only this measure.

7.8.8. The NAO report also noted that in some cases the SAP rating may have decreased following some interventions. For example, introducing an inefficient gas fire instead of an open grate would incur negative SAP points, but more than likely improve the quality of life for the recipient. This point demonstrates the conflicts between policies designed to alleviate cold and those designed to meet specific targets, in this instance on house energy efficiency.

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[140] The Warm Front Scheme, NAO, February, 2009. http://www.nao.org.uk/publications/0809/the_warm_front_scheme.aspx

[141] http://www.decc.gov.uk/en/content/cms/funding/warm_front/warm_front.aspx

7.8.9. The research work carried out by the team led by Professor Oreszczyn showed clear evidence of a certain degree of positive outcome of the Warm Front scheme. For example, the monitored temperature changes confirm that the scheme led to an increase in average living room temperatures from about 18°C to 20°C and night-time bedroom temperatures from about 16°C to 18°C. Thus the interventions achieved improvements in living temperatures bringing dwellings close to the English average.[142]

7.8.10. However, detailed measurements taken at a number of dwellings both before and after interventions and with and without interventions revealed some unexpected results.

7.8.11. The performance and impact of the interventions was both *measured* and *modelled* using a simpler but similar prediction to that used in the SAP methodology.

7.8.12. The comparison of energy consumption for space heating before and after Warm Front measures was particularly interesting. While a theoretical improvement of 25–35% in energy consumption was predicted, the actual measured improvements were negligible.

7.8.13. Considering the age of the dwelling, it was predicted that the newer the building, the lower the energy consumption, because modern buildings have a higher standard of insulation. However, actual measurements revealed that the predicted improvement only occurred for dwellings built after the introduction of the 1976 Building Regulations to control use of fuel.

7.8.14. In terms of dwelling type, the theoretical prediction was based on the assumption that the smaller the exposed surface area, the lower the heat loss. Thus the predicted increasing order of heat consumption, corrected for floor area, was flats, terraced, semi-detached, detached houses. However, the measured results revealed flats were the highest for fuel consumption followed by semis, then detached and terraced.

7.8.15. The results of insulation impacts showed too that the performance was less than expected. The theoretical prediction is that full cavity wall insulation plus full loft insulation would result in a 49% reduction in energy use, but in fact observations recorded only an 11% saving.

7.8.16. It was predicted that switching from room heaters to a new efficient central heating system should result in a 43% reduction in energy consumption for space heating. However, the empirical data shows no significant relationship between energy consumption and type of heating system.

7.8.17. Measurements of air-tightness of the dwellings before and after the interventions in some cases also failed to show the expected improvements. For example, the sample of houses where central heating was installed showed an increase in air infiltration of 13%.[143]

7.8.18. The measured data revealed that the SAP ratings were a poor indicator of actual space heating energy consumption. Surprisingly, the data would suggest that space heating fuel consumption is independent of the SAP rating of the dwellings.

7.8.19. The conclusions drawn are that the supposed energy improvements did not deliver the expected reduction in fuel consumption. There are several reasons for this.

7.8.20. The normal explanation for these differences is the so-called "comfort take back", whereby householders continue to pay the same amount, preferring to enjoy warmer conditions in their homes than savings. This would be unsurprising in the case of the Warm Front targeted group of householders, who would have been expected to have significantly colder houses than the

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[142] Oreszczyn, T., Hong, S.H., Ridley, I. & P. Wilkinson, "Determinants of winter indoor temperatures in low income households in England", *Energy & Buildings*, 38 (2006), 245-252.

[143] Sung H. Hong, Ian Ridley, Tadj Oreszczyn, "The Impact Of Energy Efficient Refurbishment On The Airtightness In English Dwellings", The Warm Front Study Group.

norm pre-refurbishment. However, these effects were recognized and had already been taken into account.

7.8.21. Some of the difference between the expected and actual energy savings was attributed to reduced air-tightness following installation of central heating; for example, installation of the pipe work was not always effectively sealed to prevent the introduction of new draught pathways.

7.8.22. Another reason was revealed by infra red thermal imaging checks on the efficacy of the insulation work. Of the cavity wall insulation inspected, an average of 20% was missing.

Figure 38: Image and infra-red image showing missing area of insulation at the top of the wall.
Source: Hong 2011.[144]

7.8.23. An average of 13% of the loft area that could have been insulated was also missing, usually in the corners and edges where access is difficult and there is concern about blocking roof vents.

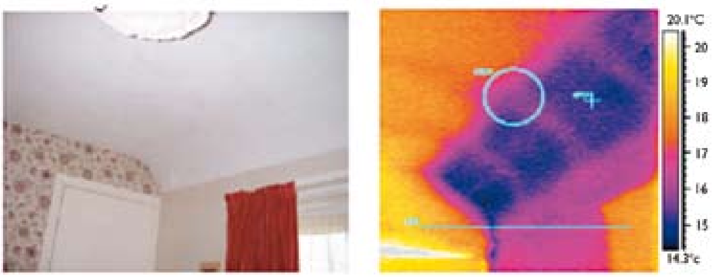

Figure 39: The missing loft insulation near the eaves.
Source: Hong 2011.[145]

7.8.24. It was also concluded that the models may overestimate energy savings by making the assumption that the efficient energy system is actually used by the householder. In practice many householders like to sit in front of a fire producing real flames and would use those sorts of fires *instead of, or in addition to,* the newly installed central heating.

7.8.25. Thus the case studies show that theoretically-derived fuel savings tend to be quite significantly overestimated in retrofitting existing buildings. The major point to take from this study is that it is vital to gather empirical data to determine the cost and effectiveness of energy efficiency measures.

7.9. Case Study 2: E.On Challenge 100

7.9.1. The energy company E.On has published results of their Challenge 100 project, the aim of which was to eradicate fuel poverty for 100 families, in 100 homes, in 100 days. The project was carried

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[144] Hong, S. H., "Changes in Space Heating Energy Consumption Following Energy Efficient Refurbishment in Low Income Dwellings in England". PhD thesis, University College London, May 2011.

[145] Hong (2011).

out on dwellings in three urban areas, Birmingham, Luton and Manchester, and two rural areas, County Durham and South Staffordshire.

7.9.2. A three-fold approach was adopted: installing energy efficiency measures largely under the Government's Carbon Emissions Reduction Target (CERT) and CESP (Community Energy Savings Programme) schemes, as well as carrying out benefit entitlement checks to increase income, and giving energy tariff advice to reduce energy costs.

7.9.3. CESP is designed as a "whole house" package of specific energy savings measures tailored for the particular dwelling. It is also designed to be implemented sequentially over successive houses and streets. However, it is restricted to specific low income urban areas.[146]

7.9.4. The energy efficiency measures installed included substantial works such as external wall insulation, new boilers and in one case a ground source heat pump. However, in some urban cases, because the dwellings were sited outside the target areas for the CESP scheme, only CERT measures could be used. These measures could not cover the cost of solid wall insulation, even though that would have been the preferred solution for the properties.

7.9.5. Whereas the average SAP rating of 50 for the urban dwellings was equal to the national average, the rural dwellings were significantly lower at 38.6 for County Durham and 15.6 for South Staffordshire. These areas were not on the gas grid and used oil, coal or electricity for heating.

7.9.6. The take-up of the offer of benefit entitlement checks was low at only approximately 20%. The householders did not understand the link between questions about benefits and improving the fabric of their dwellings and did not expect energy providers to perform that role. Consequently, they were suspicious of the exercise.

7.9.7. The report also noted certain behaviours that militated against reduced energy usage. The first, also noted by the Warm Front study, found that householders preferred to sit by a gas fire and/or have the central heating on, than rely on the more energy efficient central heating alone.

7.9.8. The second concerned pre-payment meters. Although cheaper tariffs are available, one participant in the E.On study did not wish to move from a pre-payment meter to a cheaper tariff because she had experienced fuel debt in the past, and preferred the control on spending that a pre-payment meter afforded her.

7.9.9. Another issue was that some householders refused the energy efficient refurbishments offered because they were in privately rented accommodation and feared that the landlord would increase the rent if improvements were made.

7.9.10. The study found that government policies supporting property refurbishment were inflexible and not necessarily appropriate to tackle fuel poverty. For example, the study found that where boilers were found to be dangerous and needed replacing, the cost of replacement was not covered by CESP because the original boiler was not G-rated for efficiency.

7.9.11. The same applied in another case where the external wall insulation which had been added as part of the insulation measures necessitated the boiler flue being replaced by a longer one. However, the boiler itself was obsolete and thus a flue could not be procured. The replacement of the whole boiler was not covered by CESP.

7.9.12. Also, CESP does not cover make-good costs, for example the replacement of gutters following external wall insulation or boxing in new pipe work.

7.9.13. Solid-walled houses with full loft insulation are not eligible for CERT so improvements to those houses were not covered.

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[146] For a list of the specific CESP areas see http://www.decc.gov.uk/assets/decc/consultations/cesp/1_20090630123736_e_@@_decccommunitesareasoflowincomecesp.pdf.

7.9.14. Furthermore, because rural areas usually have solid wall houses off the gas mains and therefore require more expensive measures that the existing policies did not support, the study recommended that fuel-poor customers in rural areas require special focus.

7.9.15. In terms of the original goal of eradicating fuel poverty, the study found that energy efficiency measures could pull some households out of fuel poverty. Those households that were just over the fuel poor threshold and paying 10–12% of income on energy did see sufficient improvement to come out of the fuel poor category.

7.9.16. However, those where the starting point was 15–30% remained in fuel poverty in spite of quite significant improvements in the energy efficiency of the dwellings.

7.9.17. E.On's Challenge 100 succeeded in getting 45% out of fuel poverty but "failed" for 55%. However, and this is in part a reflection on the binary nature of the conventional fuel poverty measure, improvements were made in nearly all houses. To use the terms adopted elsewhere in this study, risk of hardship was reduced in most houses, even though technical fuel poverty was not eliminated according to the conventional definition.

7.10. Case Study 3: Gentoo Retrofit Reality

7.10.1. Gentoo is a social landlord which manages around 29,500 rental properties around Sunderland. Their Retrofit Reality project looked at the effects of installing the following four energy products in 139 homes:

- Solar thermal panels
- A-rated condensing combination boilers
- Energy efficient showers
- Double glazing.

7.10.1. The 139 homes were chosen from a larger set of 1,500 homes that were due to be upgraded to the Decent Homes Plus Standard.[147]

7.10.2. The study sought to investigate ease of installation of the products, whether the homeowners found them easy to use, and information about ensuing benefits, value for money and maintenance overheads.

7.10.3. Each household was paid £100 on the understanding that they would consent to co-operate with the monitoring of energy performance of their homes for 18 months following the installation of the energy product.

7.10.4. Appropriate products depended on the particular circumstances in each household. For example, solar thermal panels were disproportionately expensive for the elderly and homes with single occupants who tended to use less hot water.

7.10.5. The characteristic of the houses often ruled out certain options. For example, solar thermal was impracticable if the roof did not face south or was over-shadowed, reducing the potential solar radiation.

7.10.6. If the roof needed strengthening then the costs of solar panels outweighed their advantage. Similarly, if the house itself did not have enough cupboard space or strong enough floors for a solar thermal hot water cylinder – which is larger and heavier than conventional hot water cylinders – then solar panels were ruled out. In some cases, a refurbishment was ruled out because it would have entailed extensive plumbing works or the gas and electricity meter relocating.

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[147] A useful description of the DCLG's Decent Homes Standard and the enhanced Decent Homes Plus Standard can be found at http://www.cdht.net/files/ART513_Decent%20Homes%20Standard.pdf.

7.10.7. Some products were positively rated by the tenants who received those measures. For example, Gentoo noted that aerated flow shower heads were liked because they give the sensation of higher volume of water and saved energy on water heating. Furthermore, recipients of showers liked them, found they saved money and improved their quality of life.

7.10.8. But low flow showerheads were not a success on electric showers because the shower unit could overheat and there was potentially too little water flow for a pleasant shower.

7.10.9. Suppliers of the different technologies were either accredited under a Government scheme or not. Interestingly, Gentoo found that some suppliers who were not accredited delivered better value for money.

7.10.10. In order to monitor the results of the retrofitted energy savings equipment, it was necessary to obtain an initial baseline energy consumption figure for each dwelling. This presented the company with logistical problems: the tenants using prepayment meters were unable to tell what past use was and those with bills could not necessarily produce them. The energy companies were apparently unforthcoming for an undisclosed reason. The solution was for the investigators to take regular meter readings.

7.10.11. These initial energy consumption figures were compared with modelled data for the dwellings using the Government's Standard Assessment Procedure (SAP). The set of dwellings treated in the study had an average SAP rating of 56.

7.10.12. On average, the tenants were using 40% less energy than the SAP procedure would have predicted but paying higher prices for that energy than the SAP model predicted. They were using more electricity and less gas than the model assumed.

7.10.13. Using *modelled* data and *actual* data Gentoo assessed the effects energy saving measures had on energy consumption and cost.

Table 9: Modelled and Actual Consumption

	Modelled Consumption	*Actual Consumption*
Before	32 MWh	18 MWh
After	21 MWh	13.5 MWh
Savings	34%	25%

Table 10: Modelled and Actual Costs

	Modelled Annual Costs	*Actual Annual Costs*
Before	£1,415	£890
After	£1,143	£784
Savings	19%	12%

7.10.14. The SAP models proved inaccurate, in part because assumptions about the number of occupants of the dwellings overstated the facts.

7.10.15. The tenants with the lowest energy use before the interventions actually achieved the lowest savings. This was explained as taking the savings as comfort. In other words those on low incomes only use as much energy as they could afford, and after the interventions they preferred to buy greater comfort rather than save money.

7.10.16. The study identified flaws in the SAP model used. It is assumed houses are efficiently heated but often householders do not understand the central heating mechanisms and the timers. The assumed efficiencies of boilers may be unduly low for the sample dwellings in the study resulting in predictions of higher gas usage. Social housing householders who tend to be unemployed or retired often spend more hours of the day at home than is assumed in the SAP methodology.

7.10.17. The interventions did have a beneficial impact on energy costs and improved the quality of life for householders, but the savings were not sufficient to make significant changes to the numbers in fuel poverty, a point which again suggests that the binary nature of the current fuel poverty definition is unhelpful.

7.11. Case Study 4: Retrofit for the Future

7.11.1. In 2009, the Technology Strategy Board, a quango funded by the Department of Business Innovation and Skills (BIS), launched a £10 million competition, "Retrofit for the Future", to reduce carbon emissions in social housing.

7.11.2. The competition was to select fifty demonstrator, whole-house solutions for the retrofitting of social housing. 100% funding for the whole project was offered. The remit was described as "Ambitious, cost-effective, carbon and energy reductions with potential widespread applicability in low rise, whole house solutions".

7.11.3. In the first phase of the competition, 190 organizations received up to £20,000 to do feasibility studies. In the next phase, 87 projects were selected to test low carbon building technology.[148] Each project will receive an average of £142,000 to demonstrate exemplary building standards to achieve high energy efficiency standards. The completed houses will be monitored for two years and the energy usage data will be available on-line.[149]

7.11.4. To date, only forecast performance of the energy efficiency of the phase 2 projects is available. The target primary energy is 115 kWh/m^2/year which implies a space heating target of approximately 40 kWh/m^2/year.

7.11.5. However, a press story describes one of the refurbishments on an end-of-terrace, Victorian house in Oxford.[150] The tenants were required to move out for six months while the house was stripped back to the exterior walls. All walls including interior walls, and floors were insulated. Doors and windows were replaced with triple glazed alternatives with insulated frames. An electrical ventilation system was installed with a heat exchanger to use stale air from the building to warm incoming fresh air. Solar thermal and solar PV panels were added to the roof.

7.11.6. Early indications are that gas usage has fallen significantly and electricity consumption has risen slightly, presumably because of the demands of the electrical ventilation system.

7.11.7. The disadvantages include some loss of space within the house, with the wall insulation resulting in both the rooms and staircase becoming narrower. Also, storage space in the loft might be lost for the insulation and ventilation shafts.

7.11.18. The cost of the refurbishment is approximately £90,000 compared with the initial value of the property of £350,000. While costs would be expected to come down for whole street refurbishments and increased knowledge of the most cost-effective measures, it is clear that refurbishment to this high standard is both costly and disruptive.

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[148] http://www.innovateuk.org/_assets/pdf/press-releases/press%20release%20retrofit%20national%20release%20-%20final.pdf

[149] http://www.retrofitforthefuture.org/

[150] http://www.dailymail.co.uk/property/article-2033877/The-350-000-Oxford-home-given-90-000-eco-makeover-bid-cut-Britains-carbon-emissions.html?ito=feeds-newsxml

7.12. Case Study 5: Edinburgh Energy Heritage Project

7.12.1. A significant proportion of the UK housing stock is 100 or more years old (21% built pre-1918), some of which is of significant historic and architectural merit. Demolition and re-building would not be desirable, economically viable or indeed energy efficient given the embodied energy in the building itself. In that context the results of the Case Studies in the Changework's Energy Heritage Project are particularly interesting. [151]

7.12.2. The project involved upgrading the energy efficiency of nine flats in a listed (B) Georgian tenement building situated within the UNESCO World Heritage Site in Edinburgh.

7.12.3. Replacing the single glazed sash windows in the building with modern double glazed units was not an option because the building was listed. Instead the consortium installed either secondary glazing or improved the draught proofing of the existing windows and refurbished the original wooden window shutters.

7.12.4. Other efficiency measures included floor insulation, top-up loft insulation, installing A-rated condensing boilers and low energy lighting.

7.12.5. The main measures were subsequently tested for their thermal efficiencies. The secondary glazing reduced energy loss to less than one third of that of the single glazed windows (the U-value dropped from 5.5 $W/m^2/°C$ to 1.6 $W/m^2/°C$).[152]

7.12.6. The draught-proofed windows with refurbished shutters more than halved the energy loss with the shutters closed (U-value 2.2 $W/m^2/°C$). While these gains cannot be achieved during daytime when the shutters would be open, shutting them reduced heat loss via the window by about 70%. It is clear that energy savings by reinstating and using shutters throughout the night hours can be worthwhile.

7.12.7. Related measurements showed that combining secondary glazing with wooden shutters reduced heat loss values to close to those achieved for triple glazing (U-value of shutters plus secondary glazing 1.1 $W/m^2/°C$).[153]

7.12.8. Measurements also showed that it is possible to achieve significant improvements in air-tightness values in carefully draught-proofed traditional sash and casement windows. Tests showed a reduction in air leakage of 86%.

7.12.9. The Changeworks study also showed that adding a good insulation on top of an existing concrete floor improved the floor's thermal performance by nearly 500% (U-value reduced from 3.5 $W/m^2/°C$ to 0.6 $W/m^2/°C$).

7.12.10. A related study[154] of the relative energy efficiency outputs obtained from use of a range of modelling tools concluded that inaccuracies in the modelled output are more likely in the case of older housing, where there are a wide range of building types, materials and construction methods.

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[151] Energy Heritage: A guide to improving energy efficiency in traditional and historic homes. http://www.changeworks.org.uk/uploads/83096-EnergyHeritage_online1.pdf

[152] Note that the U-value quoted here for secondary glazing is from the correction in the later study at http://www.historic-scotland.gov.uk/thermal-windows.pdf.

[153] Thermal performance of Traditional Windows 2010 http://www.historic-scotland.gov.uk/thermal-windows.pdf

[154] http://www.historic-scotland.gov.uk/changeworks_report-energy.pdf

7.13. Summary of Conclusions of the Case Studies

7.13.1. A common conclusion of the case studies is that the predicted data obtained from energy efficiency models often differs significantly from actual measured data. This highlights the importance of gathering empirical data to inform policy and to monitor the trajectory of policy implementation.

7.13.2. Property refurbishment needs to be carried out to high standards and monitored carefully if the intended benefits are to be realized.

7.13.3. Current policies are not always appropriately targeted, with the rural dwellers and owners of solid-walled dwellings at risk of missing out.

7.13.4. Although the measures often improved quality of life, they were not enough to make dramatic differences to the numbers in "fuel poverty" as calculated by the standard definition. This suggests that the current definition is needlessly dispiriting, and tends to obscure the real reductions in risk of hardship that energy efficiency improvements can produce.

8. Low Temperature and Ill-Health

8.1. Health Impacts

8.1.1. Writing in 2001 the authors of the *Fuel Poverty Strategy* observed that:

> Fuel poverty damages people's quality of life and imposes wider costs on the community. The most direct effects are in relation to the health of people living in cold homes.[155]

8.1.2. The current study prefers to disentangle this composite statement by noting that "fuel poverty" in the sense of "risk of hardship" may have little or no effect on health, but that "actual hardship", arising from the inability to heat a house adequately at a time of need or over a period of time most certainly does. Indeed, it cannot be disputed that cold housing has detrimental health effects, particularly for "vulnerable" groups (older people, families with children and those with long-term illnesses) since lack of adequate heating (and lighting, and access to communication) can cause living conditions which lead to ill-health, both mental and physical.

8.1.3. Low indoor temperatures, often accompanied by poor ventilation, damp and mould, have demonstrable negative physical and mental impacts on the healthy, much more so on the vulnerable. In addition, there is an increasing body of literature to suggest that there are significant positive changes in health, both mental and physical, following intervention programmes which improve living conditions.[156]

8.1.4. It is estimated that as much as 42% of the cost of the UK's major "Warm Homes" intervention between 2001 and 2008 (£109m) may be recoverable in savings to the NHS.[157] Clearly, such a claim is difficult to validate, and we would not wish to rely upon it, but it is at least not immediately implausible. Although analysis of the data has not proved to be conclusive, largely because of its amorphous nature, it is thought that "substantial public health benefits can be expected" from measures taken to improve household thermal conditions.[158]

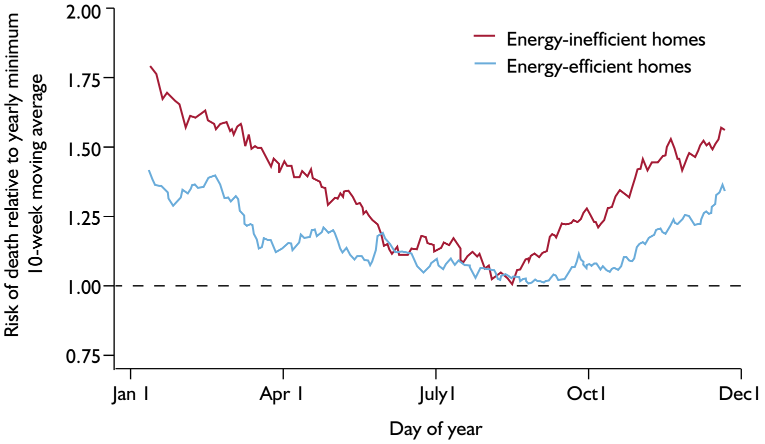

Figure 40: Risk of death relative to yearly minimum 10-week moving average in efficient and inefficient homes.
Source: Wilkinson et al. *The Lancet* (2007). Chart redrawn by REF.

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[155] DEFRA/DTI, *The UK Fuel Poverty Strategy* (2001).

[156] Shortt, N., & Rugkåsa, J. "The Walls were so damp and cold" fuel poverty and ill health in Northern Ireland: Results from a housing intervention. *Health & Place,* 13/1 (2005), 99–110.

[157] Liddell, C., *The impact of fuel poverty on children*. Policy briefing for Save the Children. (University of Ulster: 2008).

[158] Wilkinson, P., Landon, M., Armstrong, B., Stevenson, S., Pattenden, S., McKee, M. & T. Fletcher *Cold Comfort: The Social and Environmental Determinants of Excess Winter Deaths in England, 1986-1996* (Joseph Rowntree Foundation, Policy Press: Bristol, 2001).

8.1.5. In other work the same authors note that mortality figures related to older, poorly heated homes suggest the tentative conclusion that more energy efficient stock would reduce the "mortality burden" in England, and that "some research evidence and reasonable theoretical grounds" suggest that both exposure to outdoor cold and temperatures in the indoor environment are important. It is important to note that the risk of mortality is reduced in energy-efficient homes all year round and at any temperature less than the optimum.

8.1.6. It seems safe to presume that ill-health and hardship short of actual death follows similar trends. The diagram below shows "the main connections between household energy efficiency and health". The circumstantial evidence is compelling and highlights the need for further studies taking into account multiple direct (immediate term), and indirect health links.[159]

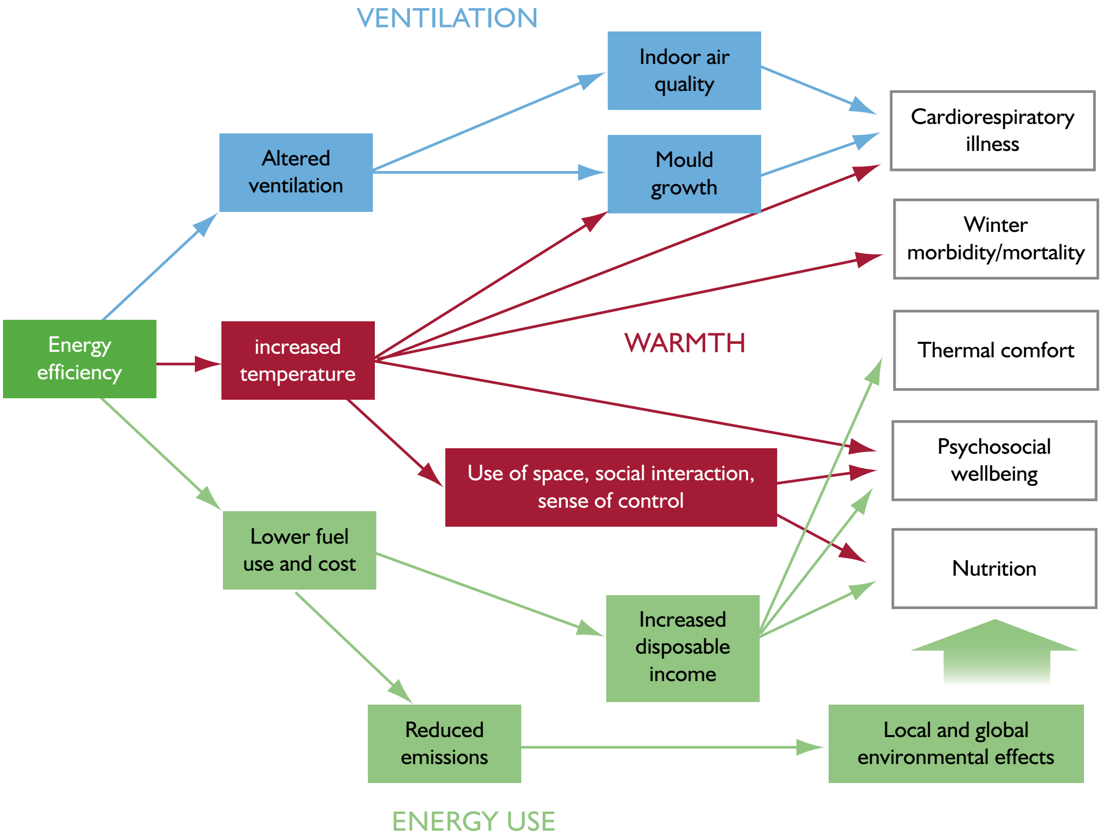

Figure 41: The Benefits of Energy Efficiency Measures.
Source: Wilkinson et al. *The Lancet* (2007). Chart redrawn by REF.

8.1.7. Overall, it would appear that the prime factor causing poor health is low indoor temperature, and associated problems stemming from inadequate indoor heating, namely damp, mould, poor ventilation, pollution, and space restrictions, though surprisingly these connections have not been studied as intensively as one might imagine:

> The association between cold homes and health has had relatively little attention […] however research that has been conducted has found an association between cold housing and respiratory illness, increased blood pressure and risk of stroke, worsening arthritis, more frequent accidents in the home, social isolation, impaired mental health and adverse effects on children's education and nutrition.[160]

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[159] Wilkinson, P., Smith, K., Beevers, S., Tonne, T. & T. Oreszczyn, "Energy, energy efficiency, and the built environment", *The Lancet* 370 (2007) 1175–1187.

[160] Shortt and Rugkåsa (2005).

8.1.8. It is worthwhile to recognize that even low levels of risk of hardship, which would not perhaps place individuals in technical fuel poverty according to the standard definitions, are also significant in terms of health:

> Living for long periods of time in [such] cold and damp conditions – rather than being fuel-poor per se – is thought to generate significant health risks.[161]

8.1.9. However, it is unclear what constitutes a low indoor temperature. As different temperatures are optimal in areas where different activities take place it is perhaps more useful to identify a "comfort zone" within which respiratory, cardiovascular and thermoregulatory systems function best.

8.1.10. The WHO recommends 18–24°C as holding no risks for healthy people, temperatures below 16°C as enhancing the risk of respiratory disorders and below 12°C as potentially leading to cardiovascular strain.

8.1.11. In the UK there are a large number of households with living conditions at temperatures below those considered safe, but, as individual housing measurements are difficult to monitor, they are largely only identifiable through intervention programmes.[162] Wilkinson suggests that "around a third of all dwellings would fail to maintain a hall temperature of greater than 16°C when the outside temperature falls to 5°C.[163] The data are currently limited and it would be beneficial if direct measurement of domestic dwelling temperatures and heating regimes could be incorporated in the English Housing Survey to better target those in jeopardy.[164]

8.1.12. The debate about an appropriate range of indoor temperatures is complicated by a number of other factors. Household members belonging to vulnerable groups, the very old or young and the disabled, may tend to stay indoors more and to have limited mobility; the recommended indoor temperatures need to be higher in such circumstances. For these groups a minimum of 20°C was recommended by WHO, and they were regarded as at severe risk below 12°C.[165]

8.1.13. In addition to the difficulty of establishing a range of temperatures considered optimal for the maintenance of good health there is also the question of subjective attitudes to temperature. Perceptions of comfort or discomfort affect both physical and psychological health. There is a school of thought that regards humans as naturally adaptive and able to adjust to a range of temperatures without jeopardizing physiological health, borne out by the wide range of environments settled and inhabited by pre-central heating and air-conditioning societies. In addition, cultural mores and technological parameters may influence ways of behaviour and attitudes to desirable temperature levels.[166]

8.1.14. Heat-waves are also responsible for increases in excess mortality. One study conducted in the Netherlands suggested that the optimum outdoor average temperature with the lowest mortality rate was 16.5°C. Mortality figures increased (from a variety of different causes) for each degree

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[161] Liddell, C. & C. Morris, "Fuel poverty and human health: a review of recent evidence", *Energy Policy*, 38 (2010), 2987–2997.

[162] Oreszczyn, T., Hong, S.H., Ridley, I. & P. Wilkinson, "Determinants of winter indoor temperatures in low income households in England", *Energy & Buildings,* 38 (2006), 245–252.

[163] Wilkinson et al., *Cold Comfort* (2001).

[164] Fahmy, E. The definition and measurement of fuel poverty: A briefing paper for Consumer Focus (2011).

[165] Rudge, J., *Indoor Cold and Mortality* (World Health Organization: 2011).

[166] Darby, S. & R. White, *Thermal Comfort: Background document for "40% house" report* (The Environmental Change Institute, University of Oxford: 2005).

Celsius decrease or increase below or above this optimum temperature.[167] Wilkinson et al. estimate that mortality rates rise by 2% for each degree Celsius fall in outdoor temperatures below 19°C.[168]

8.1.15. A Spanish study on "mortality as a function of temperature" also found that "optimum" temperatures for low mortality varied according to the season.[169] It seems that there is a strong association between temperature and mortality but this is contextual and cannot be defined as a constant in all circumstances.

8.1.16. Cold indoor temperatures cannot easily be predicted as they are dictated by a number of interacting physical (and social) factors. These were found to be the most predictive:

- Household size
- Net household income
- Geographical region
- Age of property *(properties built before 1900 were on average 2°C colder than those built after 1980).*
- Presence of central heating *(properties without central heating were 2°C colder than those with it).*
- Satisfaction with the heating system
- Cost of heating the dwelling to a minimum standard.[170]

8.1.17. There are a significant number of epidemiological studies that show links between cold temperatures in the home and increased morbidity and mortality: for example, Liddell & Morris, 2010 and Chesshire, 2002. In the UK this is reflected in the figures for Excess Winter Deaths (EWDs) and in increased hospital admissions for ailments that are cold-related, such as cardiovascular disease and respiratory disease. The UK figures for Excess Winter Deaths are high relative to other Northern European countries with much colder outdoor temperatures but better housing standards. The implication is that both indoor and outdoor temperatures account for the increased mortality and morbidity rates. Cold indoor temperatures affect specific vulnerable groups to a much greater extent than healthy adults: those over 64 years old, children, disabled people and those with chronic illnesses. According to one estimate, 93% of EWDs are among those over 64 years of age.[171]

8.1.18. The effects of cold indoor temperatures on morbidity, or increased incidence of illness, are hard to establish with statistical accuracy as the data on indoor temperatures are difficult to access and measurement of the incidence of illness and disease is estimated from indirect information such as GP consultations and hospital admissions.[172] Despite this, strong correlations have been found between cold temperatures and cardiovascular and respiratory diseases in particular, and these correlations can be extrapolated from medical studies on specific medical conditions.

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[167] Maud, H., Martens, P., Schram, D., Weijenberg, M. & A. Kunst, "The impact of heat waves and cold spells on mortality rates in the Dutch population", *Environmental Health Perspectives* 109 (2000), 463–470.

[168] Wilkinson et al. (2001).

[169] Bellester, F., Corella, D., Pérez-Hoyos, S., Sáez, M. & A. Hervás, "Mortality as a function of temperature: A study in Valencia, Spain", *Int J Epidemiology* 26/3 (1997), 1991–1993.

[170] Wilkinson et al., *Cold Comfort* (2001).

[171] Rudge, J. (2011).

[172] Rudge, J. & R. Gilchrist, "Excess winter morbidity among older people at risk of cold homes: a population–based study in a London borough", *Journal of Public Health,* 27 (2005), 353–358.

Table 11: Health risks arising from inadequately heated homes.
Source: Press (2003).[173]

Health Risk	*Effect*
Increased respiratory illness	People with asthma are two or three times more likely than the general population to live in damp homes. Temperatures below 16°C are thought to lower resistance to respiratory infection. Damp leads to growth of moulds and fungi which can cause allergies and respiratory infections. Fifteen per cent of homes report mould. The cold impairs lung function and is an important trigger of broncho-constriction in asthma and Chronic Obstructive Pulmonary Disease (COPD).
Increased blood pressure and risk of heart attacks and strokes	Blood pressure rises in older people with exposure to temperatures below 12°C. The risk of heart attacks and strokes increases with increasing blood pressure. In those aged 65-74 years, a 1°C decrease in living room temperature is associated with a rise of 1.3mmHg systolic blood pressure and a rise of 0.6mm Hg diastolic blood pressure.
Worsening arthritis	Symptoms of arthritis, particularly pain, become worse among people who live in cold, damp homes.
Increased accidents at home	Having a cold home increases the risk of falls in the elderly, and the risk of accidents due to the loss of strength and dexterity in the hands and due to open or free-standing heating. Finger strength and manual dexterity fall progressively in temperatures from 24°C to 6°C.
Increased social isolation	People may become more socially isolated due to economizing and reluctance to invite friends to a cold home. Increased social isolation is a risk factor for depression and coronary heart disease.
Impaired mental health	Damp housing is associated with increased mental health problems.
Adverse effects on children's education	Home energy improvements have led to an 80% decrease in the rate of sickness absence from school for children with asthma and recurrent respiratory infections. In many cold homes only one room is heated, which causes difficulties for children doing homework. Loss of education can lead to loss of job opportunities for life, itself a risk of early mortality.
Adverse effects on nutrition	Homes in fuel poverty have a choice between keeping warm and spending money on others essentials. Poor diet can be the result, with increased long term health risks of cancer and coronary heart disease.

8.1.19. Cardiovascular and respiratory diseases are directly associated with cold living conditions. Increased cold causes changes in blood pressure and blood chemistry which increase blood viscosity and the risk of thrombosis which can lead to heart attacks or strokes.[174]

8.1.20. Cold, damp and mould all impact on the likelihood of increased respiratory disease leading to restriction in the airways, increased mucus production and a lowering of the immune response to respiratory infection caused by stress hormones.[175] Different studies have found a prevalence of cardiac or respiratory disease linked with cold temperatures but it seems that the latter are merely more persistent over longer periods.[176]

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[173] Press, V., *Fuel Poverty + Health: A guide for primary care organizations, and public health and primary care professionals* (National Heart Forum, 2003), 19.

[174] Barnett, A. G., Dobson, A.J, McElduff, P., Salomaa, V., Kuulasmaa, K. & S. Sans, "Cold periods and coronary events: an analysis of population worldwide", *Journal of Epidemiological Community Health,* 59 (2005), 551–557.

[175] Keatinge, W. "Cold exposure to winter mortality from ischaemic heart disease, cerebrovascular disease, respiratory disease, and all causes in warm and cold regions of Europe", *The Lancet,* 349 (1997), 1341–1346.

[176] Analitis, A,. Katsouyanni, K., Biggeri, A., Baccini, M., Forsberg, B., Bisanti, L., Kirchmayer, U., Ballester, F., Cadum , E,. Goodman , P., Hojs, Q, Sunyer, J., P Tiittanen & P. Michelozzi, "Effects of cold weather on mortality: results from 15 Euro-

8.1.21. However, as shown in the table above, it is the *cumulative* health effects of low indoor temperatures which also have to be taken into account: increased risk of influenza, pneumonia, asthma, arthritis, and even accidents at home have all been implicated.[177] Both cardiac and respiratory disease cause significant public health problems in terms of the costs of health care and are the major causes of mortality.

8.1.22. Excess winter deaths (EWDs) are defined as “the number of deaths in winter (December to March) above the average for the previous and subsequent four month seasons (August to November and April to July)”. (Although in some studies the winter period is extended to include November and April, arguably a better measure as it includes unexpected unseasonal cold periods). The “Excess” is defined as observed deaths minus expected deaths.[178]

8.1.23. The link between mortality and low indoor temperatures is easier to establish than rates of morbidity as mortality figures are nationally available and there are many studies which demonstrate an association between poor housing and colder homes, and excess winter mortality (Rudge & Gilchrist, 2005; Keatinge, 1997; Wilkinson et al, 2001). “Cold effects become apparent over a relatively short time (within a week), which confirms the direct effect of cold exposure” (Kunst et al., 1993 in Rudge, 2011).

8.2. Causes of mortality

8.2.1. There are very few cases of death caused by hypothermia, which only affects victims at persistently and very low temperatures (below 6°C). Influenza is also thought of as a major cause of deaths in cold weather but was found to be responsible for less than 2.4% of 1,265 EWDs per million between 1992 and 2002.[179] As with morbidity, the majority of deaths are caused by cardiovascular and respiratory disease and by far the majority occurs in those over 65 years of age. Heart attack, stroke and other diseases of the circulation account for 40% of EWDs and about 33% are due to respiratory disease.[180] These figures vary somewhat with different sources but do not deviate far from 80% of all deaths due to cold and between 20% and 50% due to indoor cold specifically.[181]

8.2.2. The development of the effects of exposure to cold are predictable, and consequently EWDs can be estimated in relation to colder than average days (below 15°C → 0°C), as shown in the following diagram:

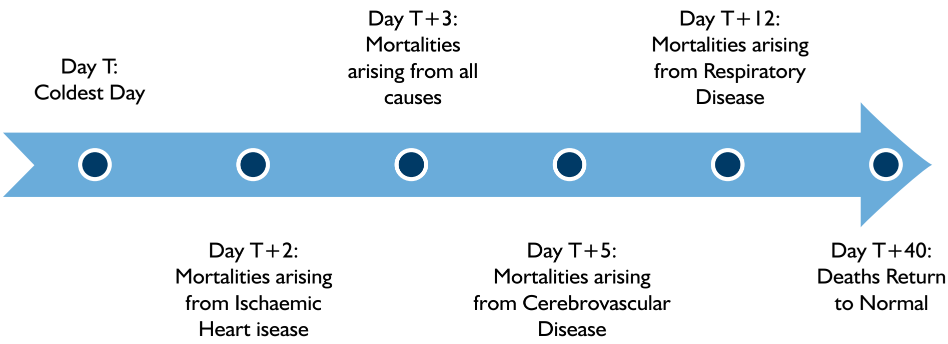

Figure 42: Mortalities and their causes subsequent to a very cold day.
Source: Donaldson & Keatinge, 1997. Chart redrawn by REF.

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pean cities within the PHEWE project”, *American Journal of Epidemiology* 168 (2007), 1397–1408.

[177] Liddell & Morris (2010).

[178] Rudge, J., (2011), 81.

[179] Donaldson, G. & W. Keatinge, “Excess winter mortality: influenza or cold stress?”, *BMJ,* 321 (2002), 89–90.

[180] *Annual Report of the Chief Medical Officer* (Department of Health: 2009).

[181] Press, (2003).

8.2.3. Although there is no absolute consensus about the relationship between cold indoor temperatures and EWDs, there is a strong correlation between cold *outdoor* temperatures and mortality and a strong correlation between inadequate housing and EWDs. Approximately 40% of annual EWDs can be attributed to bad housing conditions.[182] Wilkinson et al. looked at EWDs in relation to socioeconomic status, dwelling characteristics and energy efficiency, and indoor temperatures. They found that "the strongest association was seen with low indoor temperature, there being a 20% difference in excess winter death between coldest and warmest houses". In fact, there was a greater correlation between low temperatures and mortality than between lower socioeconomic status and mortality, indicating something of the complexity of the relationship between income and housing in relation to EWDs.[183]

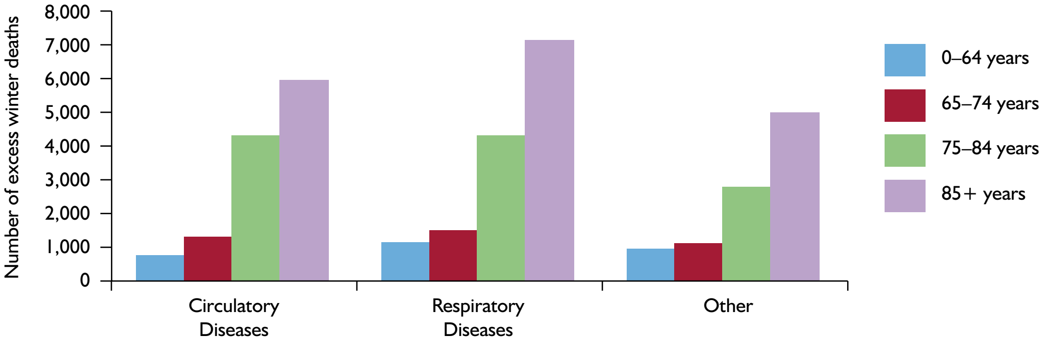

Figure 43: Number of excess winter deaths by cause and age group 2008/09, England and Wales. Source: Hills, J., *Fuel Poverty: The problem and its measurement* (CASE Report: October, 2011): 72. Chart redrawn by REF.

8.2.4. The following three graphs show EWDs for England and Wales, Northern Ireland and Scotland plotted against average winter temperatures:

England and Wales

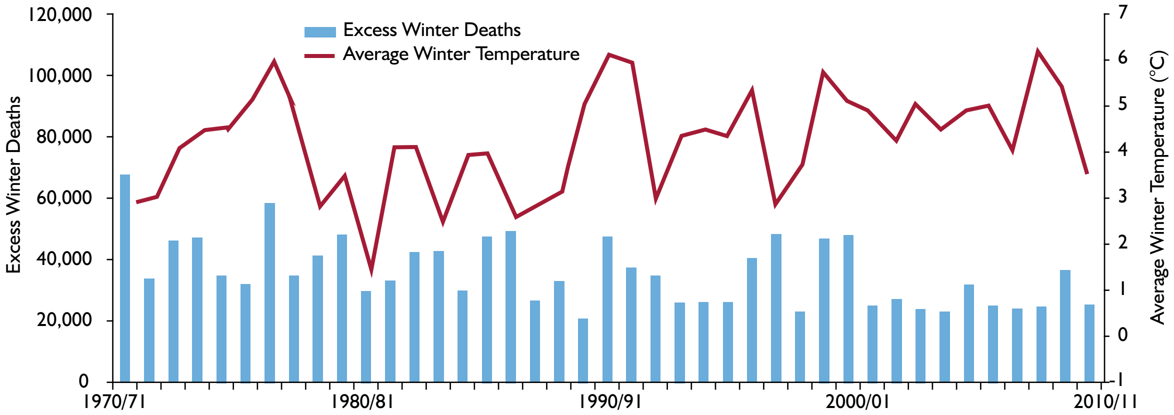

Figure 44: Excess winter deaths and average winter temperatures, 1970/71–2009/10, England and Wales. Source: Hills, J., *Fuel Poverty: The problem and its measurement* (CASE Report: October, 2011) 71. Chart redrawn by REF.

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[182] World Health Organization, Regional Office for Europe, *Housing, energy and thermal comfort* (2007), 10.

[183] Wilkinson et al. (2001)

Northern Ireland

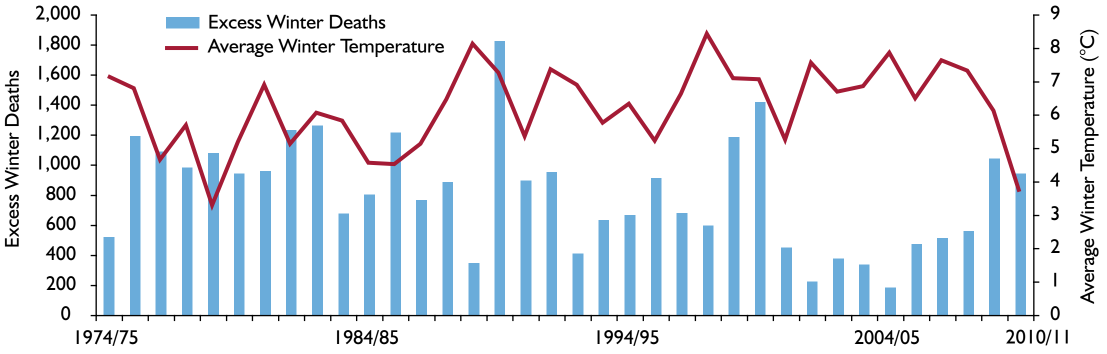

Figure 45: Excess winter deaths and average winter temperatures, 1974/75–2009/10, Northern Ireland. Source: http://www.metoffice.gov.uk/climate/uk/datasets/Tmean/date/Northern_Ireland.txt. Excess Winter Death figures from the Northern Ireland Statistics and Research Agency. Chart: REF.

Scotland

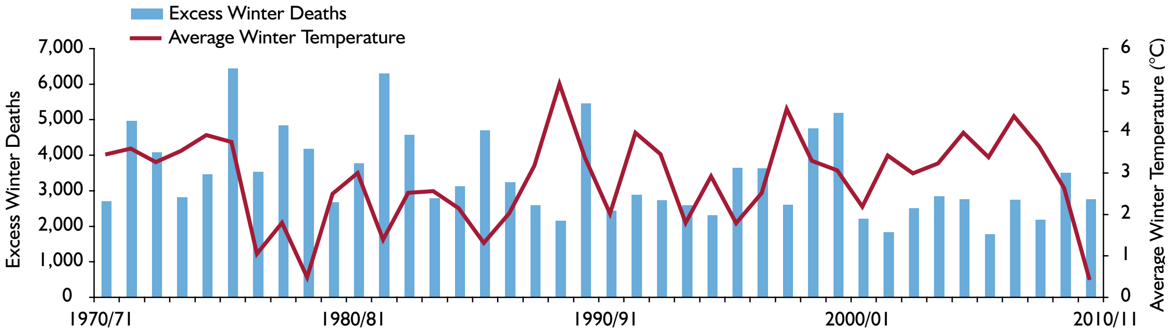

Figure 46: Excess winter deaths and average winter temperatures, 1970/71–2009/10, Scotland. Source: Figures from the General Register Office for Scotland. Chart: REF.

8.2.5. It is interesting to note that the correlation between *average* winter temperatures and EWDs is not always robust, largely because periods of unexpected temperature change, "cold snaps" and rapid changes, seem to affect health more significantly than sustained, and predictable, periods of cold. Relative temperature change rather than absolute low temperatures have negative health impacts.[184] It is the "unpreparedness" of a population that seems to render it more vulnerable.[185] As will be shown below, since northern European countries are used to dealing with extremely cold winters and are equipped in terms of housing, clothing and custom, they are not caught by surprise and sustain far fewer deaths and illnesses than warmer countries such as Ireland, Portugal, Greece and the United Kingdom.

8.2.6. Keatinge, in a survey of the relationship between disease and cold throughout Europe, found that there were "direct associations between mortality indices and protective measures against cold", and that excess winter mortality could be reduced substantially by improved protection from cold, "particularly in countries with warm winters where the need for cold-avoidance was less obvious."[186] He also plotted the increased number of deaths from all causes for each 1°C drop in temperature below 18°C and found that "mortality increased to a greater extent with a given fall of temperature in regions with warm winters, in populations with cooler homes, and among people who wore fewer clothes and were less active outdoors".

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[184] Rudge, J. (2011).

[185] Snodin, H. *Fuel poverty in Great Britain, Germany, Denmark and Spain – relation to grid charging and renewable energy* (Xero energy for Highlands and Islands Enterprise: 2008).

[186] Keatinge (1997).

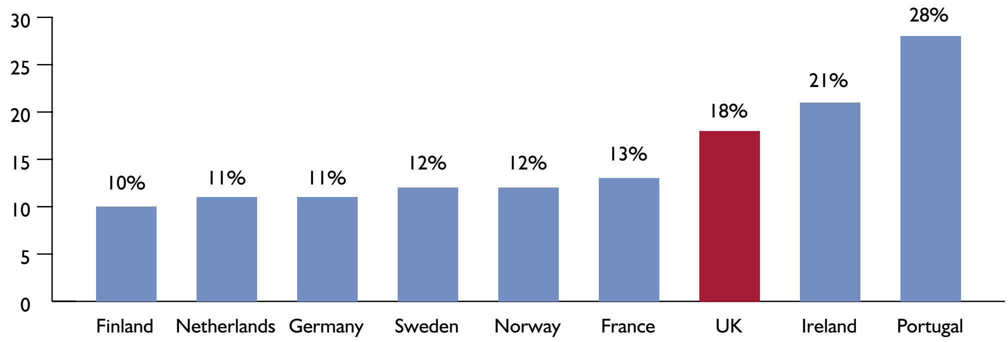

Figure 47: Average proportion of winter deaths that are excess, 1988-1997, selected European countries. Source: John Hills, *Fuel Poverty: The problem and its measurement* (CASE Report: October, 2011), 71. Chart redrawn by REF.

8.2.7. This counter-intuitive result, that there are more winter deaths in Southern and Western European countries with milder winter temperatures than in considerably colder Northern and Eastern ones, is widely recognized, Healy refers to it as "the paradox of winter mortality".[187] The figures for EWDs across nations reflect this (see diagram), and it is startling to note that relative excess deaths in the UK are nearly double those found in Scandinavian countries. The reasons for these discrepancies are not difficult to find, and there certainly seems to be a strong positive correlation between low excess winter deaths and measures taken to ensure domestic thermal efficiency.

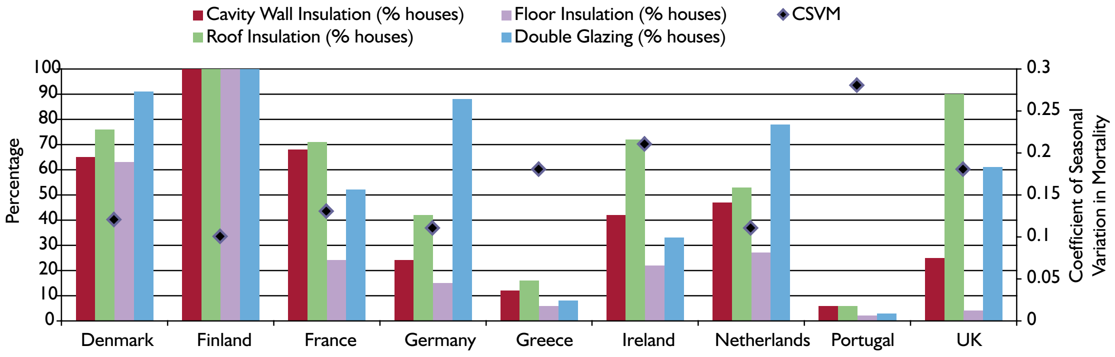

Figure 48: Coefficient of Seasonal Variation in Mortality and Domestic Thermal Efficiency. Source: Marmot (2011).[188] Chart redrawn by REF.

8.2.8. Healy also examined other potential "causal" factors and compared excess winter mortality with non-seasonal mortality in respect to other variables. EWD rates do not seem to be influenced by per capita expenditure on education or smoking or obesity. However, there is a strong correlation between public health expenditure and relative excess winter mortality.

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[187] Healy, J. "Excess winter mortality in Europe: a cross country analysis identifying key risk factors", *Journal of Epidemiology and Community Health,* 57 (2003) 784-789.

[188] M. Marmot, *The Health Impacts of Cold Homes and Fuel Poverty* (Friends of the Earth: 2011), 26.

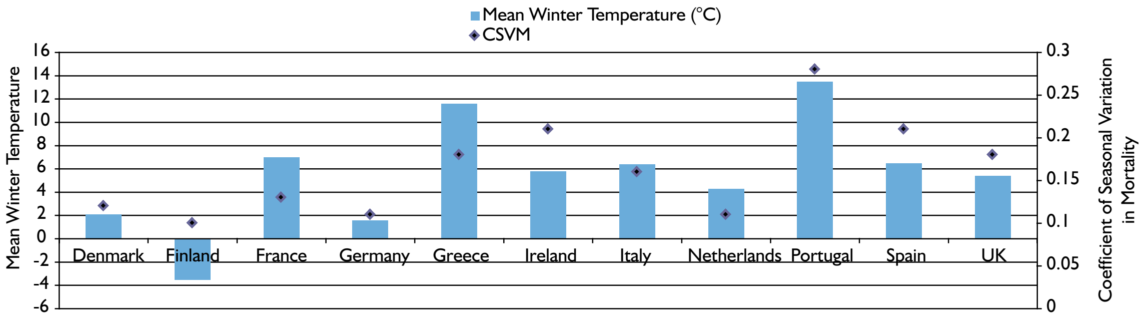

Figure 49: Coefficient of seasonal variation on mortality and mean winter temperatures for select European countries.
Source: Healy (2003). Chart redrawn by REF.

8.2.9. If EWDs can be taken as a reliable indicator of the effects of “fuel poverty”, namely occurrence of actual hardship, then it seems that these are caused by the interrelationship between poor housing, unpreparedness for low winter temperatures, low per capita health expenditure and rising energy costs against falling incomes. It is also relevant to note that in a study on the vulnerability to winter mortality amongst elderly people in Britain, Wilkinson et al. concluded that:

> Except for female sex and pre-existing respiratory illness, there was little evidence for vulnerability to winter death associated with factors thought to lead to vulnerability. The lack of socioeconomic gradient suggests that policies aimed at relief of fuel poverty may need to be supplemented by additional measures to tackle the burden of excess winter deaths in elderly people.[189]

8.2.10. The major cause of excess winter deaths has been shown to be low ambient temperatures and people in lower socioeconomic groups do not on average have cooler homes than people in higher socioeconomic groups, on which point Wilkinson and his co-authors comment that “This may reflect behavioural influences, but also the fact that housing association and local authority dwellings are often as well, or better, heated than owner occupied dwellings.”

8.3. Mental Health and Wellbeing

8.3.1. The direct physical effects of living in cold, inadequate housing have been referred to above, but the effects on the mental health and wellbeing are also significant. Mental health and wellbeing lie at the root of most if not all aspects of individual and social life, a circumstance acknowledged in the Government’s mental health outcomes strategy:[190]

> Good mental health and resilience are fundamental to our physical health, our relationships, or education, our training, our work and to achieving our potential.

8.3.2. The importance of these matters has been recognized for some time, and the UK Government Office for Science commissioned the 2008 *Foresight Project on Mental Capital and Wellbeing* to examine ways in which the United Kingdom can maximize its mental resources in the face of the rapidly changing demands of the next twenty years. Mental health and wellbeing are here regarded as of prime importance to the general health and social functioning of the populace. The project looked at ways in which policies could address and improve mental health outlooks from childhood to old age, and the importance of the physical environment which

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[189] Wilkinson, P., Pattenden, S., Armstrong B., Fletcher, A., Kovats, R., Mangtani, P & A, McMichael, “Vulnerability to winter mortality in elderly people in Britain: population based study”, *BMJ* (2004), 329.

[190] Department of Health, *No Health Without Mental Health: a cross-government mental health outcomes strategy for people of all ages* (February 2011).

families inhabit, including the necessity for good housing quality and warmth, were recognized as prerequisites for optimizing human wellbeing and child development.[191]

8.3.3. As with physical health, the associations between inadequate housing (low indoor temperature) and mental health outcomes are complex. Elucidating these relationships empirically is complicated by the interactions of different forms of deprivation that tend to compound and magnify difficulties. Low incomes, unemployment, social isolation, poor education, overcrowding and debt are the cause as well as the effect of ill health, anxiety and depression.[192]

8.3.4. All age groups are affected by different manifestations of mental stress; older adults tend to become more isolated, and the effect on children and adolescents is both pernicious and socially damaging as children brought up in such circumstances tend to run a greater risk of long-term physical and mental difficulties in the future. Again, studies of interventions and the analysis of their efficacy enable us to observe the effects of deprivation.

8.3.5. It is the more common manifestations of poor mental health, Common Mental Disorder (CMD), stress, anxiety, and depression rather than chronic and severe diseases that are associated with poor housing, low indoor temperatures and the inability to pay energy bills.

8.3.6. For obvious reasons, sufferers from chronic mental health conditions frequently live on low incomes and at risk of energy hardship. This is a self-perpetuating cycle: poor living conditions and financial problems lead to ill-health and depression, effects which are mutually reinforcing, resulting in time off work or unemployment and, frequently, to increased social isolation. As Harris et al. write:

> These disorders (CMDs) not only result in considerable distress for the individual with the condition, but can also affect their family, friends, and working life. CMD presents a substantial public health and economic cost. It accounts for one-fifth of all general practice consultations and one-third of days lost from work due to poor health in the UK […]. Reducing the prevalence of these disorders is a key public health priority.[193]

8.3.7. As well as poor housing and lack of comfort, debt is also a major contributory factor in mental health problems. "The cycle between debt and mental illness' is widely recognized, and it is important to note that the Foresight study found that "debt is a much stronger risk factor for mental disorder than low income".[194] Perhaps unsurprisingly, the Warm Front study group found that relief from financial pressures is associated with better psychosocial health.

8.3.8. The personal suffering and hardship in these cases also implies a monetary cost to the country, not least because the costs of caring for the consequences of mental ill-health are considerable.

8.3.9. The annual costs from mental ill-health in England alone have been estimated at about £35 billion (US$62 billion) in terms of direct economic costs, rising to £77 billion when wider and indirect impacts are considered, such as a reduction in quality of life. It is at least arguable that measures to improve mental health would therefore yield benefits well in excess of costs.[195]

8.3.10. The results of studies carried out on intervention programmes show considerable gains in individual health and socialization for adults and for children. Warm Front showed that people after intervention were more relaxed and content, emotionally secure and less prone to minor illness.[196] This suggests that some at least of the costs of mental-ill health and its consequences

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[191] Government Office for Science, Foresight Mental Capital and Wellbeing Project, *Final Project Report* (2008).

[192] Hood, E., "Dwelling disparities: how poor housing leads to poor health", *Environmental Health Perspectives* 113/5 (2005), A113. Liddell et al. *Kirklees Warm Zone* (University of Ulster: 2011).

[193] Harris et al. (2010). *Health, mental health and housing conditions in England.* National Centre for Social Research.

[194] Foresight Mental Capital and Wellbeing Project (2008), 21.

[195] Beddington et al. (2008).

[196] Marmot Review Team *The Health Impacts of Cold Homes and Fuel Poverty* (2011).

could be recouped by directly addressing the problems associated with poor housing and low incomes. The positive effects observed from the Warm Front study showed that:

> Occupants maintaining bedroom temperatures at 21°C were 50% less likely to suffer high levels of psychological distress than those with temperatures less than 15°C and that stress engendered by the inability to pay bills was the strongest indicator of anxiety and depression.[197]

8.3.11. Of course, mental health is interlinked with many aspects of social and individual living, with no single cause or solution. A Scottish study on local regeneration concluded that:

> In both arms of the study, health and well-being was understood as an emergent quality of a holistic approach to regeneration, rather than a direct consequence of a single intervention or approach.[198]

8.3.12. However, there is no doubt that the provision of warm and dry housing and the alleviation of anxiety about the ability to pay (fuel) bills are significant and beneficial contributions towards improving personal mental health, but wider social issues relating to health care, education, employment and a better local environment all impact on mental health outcomes. Despite this, Harris et al. concluded that:

> Even after controlling for a range of financial and socioeconomic factors including income, debt and tenure: cold housing remained independently predictive of poor mental health.[199]

8.3.13. These authors go on to add that if mental health is regarded as "fundamental" and a "key public health priority" then this fact should lead to:

> […] a policy focus not just on poverty alleviation but also specifically on improving the insulation and heating efficiency of homes, programmes like Warm Front.[200]

8.4. Mental Health Effects on Adults

8.4.1. The interim Hills Review observes that "There is strong evidence of a direct link between poor mental health and living in a cold home for adults".[201] Stress is probably the most important driver of anxiety and depression and stress is exacerbated by ill health, financial worries and the *perception* of cold and poor comfort levels. It is revealing that the association between stress and recorded temperatures was found to be less strong than that between stress and self-reported comfort levels, which suggests that perception of cold may be more important than actual temperatures in terms of mental health effects.[202] The evidence collected relies on subjective data, which in this instance may be more indicative of a "state of mind" fostered by stressful living conditions.

8.4.2. The Hills review interim study also examined a series of studies on mental health and fuel poverty. As with data on the relationship between physical health and cold temperatures, it was found that there was an "association" between under-heated homes and CMDs and a relationship between the presence of mould in the home and CMDs. There was also a strong association between an inability to pay fuel bills and high stress levels (correlated with anxiety and depression).

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[197] Green & Gilbertson, *Warm Front Better Health: Health impact evaluation of the Warm Front Scheme* (Sheffield Hallam University: 2008).

[198] Beck et al., "How will area regeneration impact on health? Learning from the GoWell study", *Public Health* 124 (2010), 125-130.

[199] Harris et al., *Health, mental health and housing conditions in England* (National Centre for Social Research 2010).

[200] Harris et al. (2010).

[201] Hills, J., *Fuel Poverty: The Problem and its Measurement* (2011), 47.

[202] Hills 2011, 47.

8.4.3. The incidence of mental disease is surprisingly high, as many as sixteen percent of adults were found to suffer from a CMD, such as depression, at any one time.[203] In 2000 a study in the *British Journal of Psychiatry* estimated the total cost of depressive disorder and recurrent depressive disorder in the UK at approximately £9 billion, of which 90% of the costs were morbidity costs.[204] Estimates have increased dramatically since then, (see below).

8.4.4. Harris et al. used a comprehensive measure of mental health (the Adult Psychiatric Morbidity Survey) in relation to "fuel related poverty" in a large general population sample to assess links between the two. They concluded that the three of the four "aspects" of fuel poverty they identified: cold home, mould in home, using less fuel than necessary for warmth, were strongly associated with the presence of CMDs. All are agreed that there is a need for a thorough, systematic, epidemiological assessment of mental disorder to test these associations.

8.5. Mental Health in Childhood and Adolescence

8.5.1. Bad housing, defined as overcrowded accommodation, accommodation in poor state of repair and inadequately heated accommodation, affects both the physical and mental health of children and adolescents:[205]

Table 12: Age Group and the Effects of Fuel Poverty

Age Group	*Effects of Fuel Poverty*
Infants	Infants brought up in fuel poor households were 30 percent more likely to be admitted to hospital or primary care clinics, they are also 29 percent more likely to be underweight.[206]
Children	Consume less or less nutritious food so that their parents can afford heating in winter. Particular vulnerability to meningitis, TB, asthma and respiratory diseases, due to cold living conditions[207] (Chief Medical Officer, 2009). May miss out on school due to their continued ill-health, their education suffering as a result (Liddell, 2008).
Adolescents	Fuel poverty increases adolescent risk taking behaviour such as early alcohol consumption, tobacco dependence and truancy. Cold homes result in four or more negative outcomes in adolescent mental health (Barnes, 2008). 28% were at significant mental health risk, compared with 4% of similar children who lived in homes that were adequately heated (Liddell, 2008). Ten percent of teenagers living in fuel poor households felt unhappy in their family as compared with 2% of similar teenagers living in warmer homes. Adolescents in poorly heated houses are also twice as likely to run away from home (Liddell, 2008).

8.5.2. As pointed out by the Marmot Review Team, the physical and mental effects of living in bad housing are particularly pernicious for children and adolescents. These effects may also prejudice their long-term prognosis for good health and personal achievement in later life. Other

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[203] Beddington et al., "The mental wealth of nations", *Nature* 455/23 (2008), 1057–1060.

[204] Thomas & Morris, "Cost of depression among adults in England in 2000", *The British Journal of Psychiatry* 183 (2003), 514–519.

[205] Barnes, et al., *What happens to children in persistently bad housing? (*National Centre for Social Research: 2008).

[206] Liddell, C., *The Impact of Fuel Poverty on Children* (Save the Children: 2008).

[207] *Chance of a Lifetime: The Impact of Bad Housing on Children's Lives* (Shelter: 2006).

research indicates that there is a connection between poor living conditions in childhood, both physical and psychological, and illness and mortality in later life (for example heart disease):[208]

> […] not only is housing quality associated with psychological health in children, it may also affect certain aspects of children's motivation. Children who live in poorer quality housing are less likely to persist on an age-appropriate, challenging puzzle. This association occurs independently of income.[209]

8.5.3. There is also a marked connection between reduced educational achievement and bad housing. Cold, damp and mould lead to more minor ailments as well as respiratory diseases that cause children to take time off school. Psychological distress caused by living in poor conditions lead to anxiety and depression and may lower performance. Lack of privacy lowers concentration and inhibits the ability to do homework. This lack of privacy impacts on adolescents in particular as they are more likely to spend time out of the house encouraging both risk-taking behavior and truancy.[210]

8.6. The Costs of Mental Health Care

8.6.1. The annual cost of mental illness in terms of treatment, impairment of life quality, future opportunities and working days lost is extremely high. Indeed, these problems carry a bigger cost to society than crime.

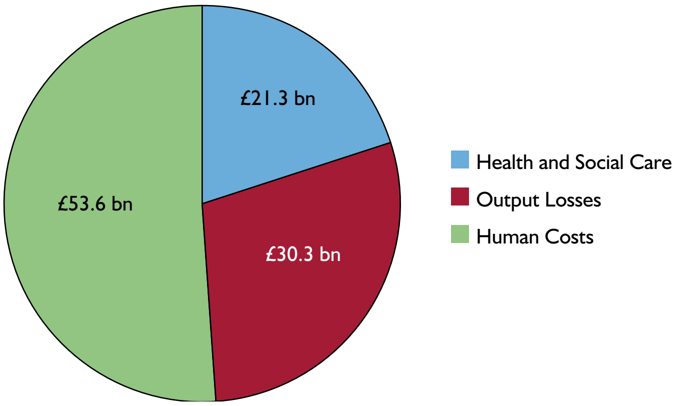

Figure 50: Costs of Mental Illness in England, 2009–2010.
Source: The Sainsbury Centre for Mental Health.[211] Chart redrawn by REF.

8.6.2. Such costs ensure that mental ill-health will continue to be a priority issue for public policy, not least because public expenditure on mental health services amounts to about one tenth of the total cost described in the chart above.[212]

8.6.3. The links between poor and cold housing and mental health, particularly CMDs, although not exactly quantifiable, are established, and a significant percentage of the costs of mental ill-health could be averted if more attention were given to the quality of accommodation and the alleviation of stress related to debt, energy costs and social exclusion. These savings would benefit both individuals directly affected and society as a whole. The portion of the combined costs of physical and mental ill-health attributable to sub-standard housing alone would, in the view of some commentators, justify the institution of new retrofit and energy savings programmes.

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[208] Lundberg, O., "The impact of childhood living conditions on illness and mortality in adulthood", *Soc. Sci. Med*, 36/8 (1993), 1047-1052.

[209] Evans et al., *Housing Quality and Children's Socioemotional Health (2001), 389.*

[210] *Chance of a Lifetime: The Impact of Bad Housing on Children's Lives* (Shelter: 2006).

[211] Policy Paper 3 (October 2010).

[212] Centre for Mental Health, "The economic and social costs of mental health problems in 2009/10" (Centre for Mental Health: 2010).

A recent BRE cost-benefit analysis suggests that tackling only the worst SAP-rated houses in England (EER bands F and G) would pay for itself in NHS savings after 18 years in a medium risk model.[213]

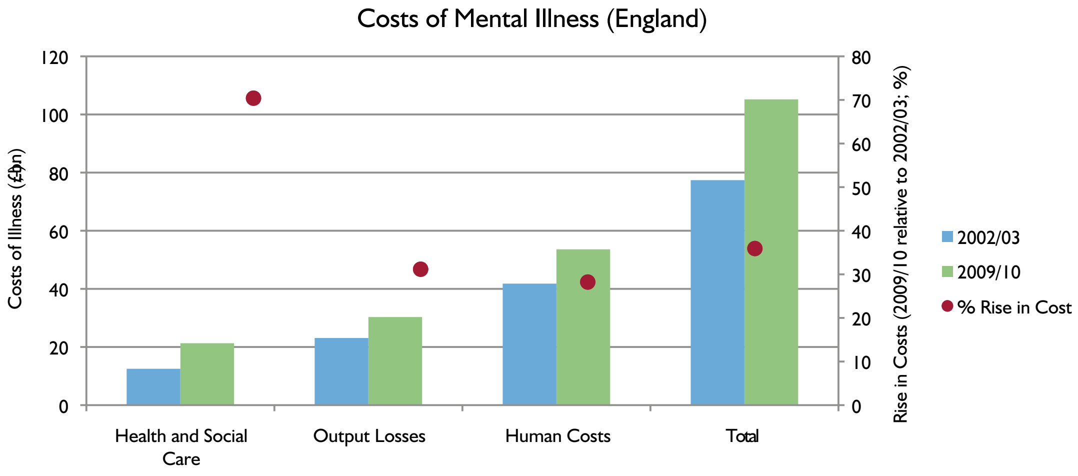

Figure 51: Costs of Mental Illness in England.
Source: Adapted from *The Economic and Social Costs of Mental Illness*, The Sainsbury Centre for Mental Health, 2003 and *The Economic and Social Costs of Mental Health Problems in 2009/10*, The Centre for Mental Health, October 2010.

8.7. Conclusion

8.7.1 Actual hardship arising from the fact that adequate heating is unaffordable in a particular building at a particular time or over a timespan has straightforwardly physical and psychological components. Simple physical effects range progressively from discomfort through to mortality, with psychological effects that are broad in character and with a very wide range of consequences.

8.7.2 It is this real, concrete, range of facts relating to actual hardship, that properly motivates much if not all concern about energy affordability.

8.7.3 Less acute, though in some senses equally important, is hardship that arises due to constrained resources after purchasing adequate energy. Such matters are intrinsically heterogeneous, and leave no unequivocally attributable traces similar to the health effects that result from the failure to purchase adequate warmth. Addressing this chronic hardship is undoubtedly challenging but necessary for a healthy, vigorous society, and robust economy.

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[213] Liddell, C. *Defining Fuel Poverty in Northern Ireland: a Preliminary Review* (2011).

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Appendices

Appendix 1: List of UK Energy Policies and Measures from the EC MURE Database

Reference: http://www.isisrome.com/mure/index.htm

MURE Category	*Policy Title*	*Status*
General cross-cutting	Climate Change Act	Ongoing
General cross-cutting	Energy Act 2010	Ongoing
General cross-cutting	Environmental Transformation Fund	Ongoing
General cross-cutting	EU-related: Promotion of the Use of Energy from Renewable Sources (Directive 2009/28/EC) – National Renewable Energy Action Plan (NREAP)	Ongoing
General cross-cutting	Feed In Tariff	Ongoing
General cross-cutting	Green Deal	Unknown
General cross-cutting	Housing Act 2004	Ongoing
General cross-cutting	Low Carbon Transition Plan	Ongoing
General cross-cutting	Renewables Obligation	Ongoing
Household	Act CO_2 Campaign	Ongoing
Household	Carbon Emissions Reduction Target (CERT) & Suppliers obligation (Former EEC 3)	Ongoing
Household	Community Energy Saving Programme (CESP)	Ongoing
Household	Decent Homes Standard – a minimum standard that triggers action to improve social housing	Ongoing
Household	EU-related: Energy Labelling of Household Appliances (92/75/EC)	Ongoing
Household	EU-related: Energy Performance of Buildings (2002/91/EC)	Ongoing
Household	Home Energy Conservation Act 1995 and Energy Conservation Act 1996	Ongoing
Household	Household Sector: Microgeneration	Ongoing
Household	National Grid Affordable Warmth Solutions	Ongoing
Household	Reduction in VAT rate for energy saving materials	Ongoing
Household	Smart Metering and Billing	Ongoing
Household	Stamp Duty – No stamp duty on zero carbon homes	Ongoing
Household	The Energy Saving Trust (various initiatives)	Ongoing
Household	Warm Front and Fuel Poverty Programmes	Ongoing
Household	Zero Carbon Buildings (government targets and Zero Carbon Hub)	Ongoing
Industry	Climate Change Agreements	Ongoing
Industry	EU-related: Combined Heat Power (Cogeneration), Directive 2004/8/EC	Ongoing
Industry	EU-related: Community framework for the taxation of energy products and electricity (Directive 2003/96/EC) – Climate Change Levy	Ongoing
Industry	EU-related: EU Emission Trading Scheme (2003/87/EC)	Ongoing
Industry	EU-related: Integrated Pollution Prevention and Control IPPC (Directive 2008/1/EC)	Ongoing

Industry	The Carbon Trust – (Various initiatives)	Ongoing
Industry	The Enhanced Capital Allowance Scheme	Ongoing
Tertiary	Building Schools for the Future	Ongoing
Tertiary	Carbon Reduction Commitment Energy Efficiency Scheme (CRC EES)	Ongoing
Tertiary	Carbon Trust – Various Initiatives	Ongoing
Tertiary	Climate Change Agreements	Ongoing
Tertiary	Climate Change Levy	Ongoing
Tertiary	EU-related: Energy Performance of Buildings	Ongoing
Tertiary	EU-related: Energy Performance of Buildings – Building Regulations 2010	Ongoing
Tertiary	EU-related: Energy Performance of Buildings – Energy Performance Certificates	Ongoing
Tertiary	Public Sector financing through Salix	Ongoing
Tertiary	Public Sector Procurement Standards	Ongoing
Tertiary	Smart metering and Billing for SMEs	Proposed (advanced)
Tertiary	Sustainable Operations on the Government Estate (SOGE Targets)	Ongoing
Tertiary	Sustainable Schools Action Plan	Ongoing
Tertiary	The Energy Saving Trust – (Various Initiatives)	Ongoing
Tertiary	The Enhanced Capital Allowance Scheme	Ongoing
Transport	EU-related: Fiscal Measures to Promote Car Fuel Efficiency – Graduated Vehicle Excise Duty	Ongoing
Transport	EU-related: Fiscal Measures to Promote Car Fuel Efficiency – Company Car Taxation	Ongoing
Transport	EU-related: Passenger Car Labelling on fuel economy rating (Directive 1999/94/EC) – UK Fuel Economy Labels for new and used cars	Ongoing
Transport	EU-related: Promotion of Biofuels or other Renewable Fuels for Transport (Directive 2003/30/EC) – Fuel Duty Levels	Ongoing
Transport	EU-related: Promotion of Biofuels or other Renewable Fuels for Transport (Directive 2003/30/EC) – Renewable Transport Fuels Obligation	Ongoing
Transport	EU-related: Speed limitation devices for certain categories of motor vehicles (Directive 2002/85/EC) – Speed limiter for Goods Vehicles and Buses	Ongoing
Transport	Freight Facilities Grant (closed 2011)	Completed
Transport	Smarter choices (closed Apr 2009)	Completed
Transport	Low Carbon Vehicle Partnership	Ongoing
Transport	Energy Saving Trust: Transport Initiatives	Ongoing
Transport	Transport Innovation fund (closed 2010)	Completed
Transport	Act on CO_2 (Transport) Campaign and Eco Driving	Ongoing
Transport	Speed Limits and Active Traffic Management	Ongoing
Transport	National supporting fiscal measures for the EU voluntary agreements for car CO_2	Ongoing

Appendix 2: Heating in Great Britain

Heating in Great Britain by Country and Fuel Type, 2005. Source: BRE, *Domestic Energy Fact File* (2008).[214]

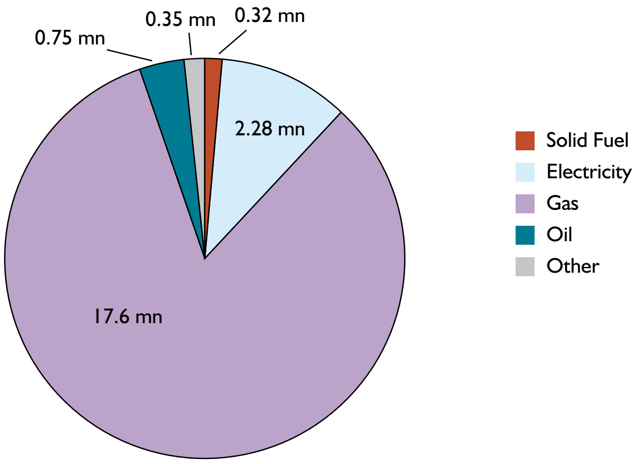

Figure 52: Heating in England by fuel type, 2005.
Chart: REF.

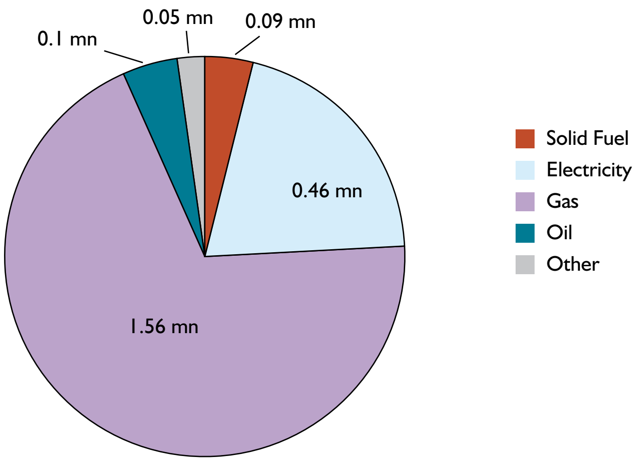

Figure 53: Heating in Scotland by fuel type, 2005.
Chart: REF.

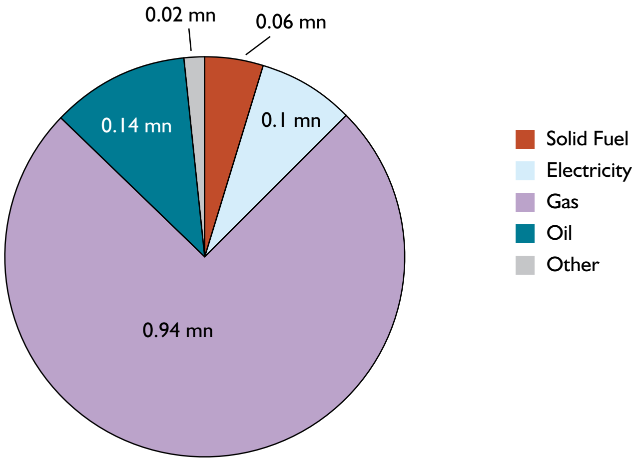

Figure 54: Heating in Wales by fuel type, 2005.
Chart: REF.

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[214] BRE, *Domestic Energy Fact File* (2008). http://www.bre.co.uk/filelibrary/pdf/rpts/Fact_File_2008.pdf.

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