SHORTFALL REBOUND BACKFIRE

Can we rely on energy efficiency to offset climate policy costs?

Shortfall, Rebound, Backfire

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About Renewable Energy Forum Ltd and this Study

Calor Gas Ltd has commissioned Renewable Energy Forum to review the government's proposed energy efficiency measures with a view to assessing their probable benefit to consumers as a means of offsetting the cost impacts of energy and climate change policies.

Renewable Energy Forum Limited (REF Ltd) is a wholly-owned subsidiary of Renewable Energy Foundation, a UK registered research and education charity.[1] Through its consultancy work REF Ltd aims to generate income to support the Foundation in its charitable objectives.

The study has been conducted and written for REF Ltd by Dr John Constable, Dr Lee Moroney, and Diana Beatty. We wish to acknowledge the invaluable assistance of Ava Ichaporia and Simranjit Jain. A former Renewable Energy Foundation volunteer, William Kelley, now undertaking postgraduate research at St John's College, Oxford, contributed the section on W. S. Jevons.

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Please note that this online version of Shortfall, Rebound, Backfire *includes a comprehensive bibliography, starting on page 49. The bibliography was omitted from the printed version for reasons of space.*

1 See www.ref.org.uk.

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1. Introduction

This study discusses the government's apparent assumption that the costs of the UK's energy and climate change policies will be offset by energy efficiency measures, both in domestic households and in businesses, leading to a reduction in energy consumption (i.e. energy conservation). The following three terms appear widely in our discussion:

Shortfall

By "shortfall" we mean the degree to which an energy efficiency measure fails to operate at the expected level, or under-performs in real world conditions, resulting in smaller energy savings than are anticipated by an engineering analysis or policy models.

Rebound

By "rebound" we mean the tendency of a user, which might be an individual or a household or a business, to use more of an energy service when it becomes cheaper because of an efficiency improvement. For example, a household might tend to heat more of a house to higher temperatures after applying insulation. In the domestic sector and in relation to heat this is sometimes referred to as "comfort taking". Rebound reduces the energy saving expected from the measure.

Some authors would describe this as "direct rebound", and use the term "indirect rebound" to refer to the increases in energy consumption in a household or a business that result from the fact that money has been saved, and may be spent on some other energy-consuming activity. For example, a household the energy bills of which had fallen might choose to eat out more often, thus increasing energy consumption in the wider economy.

Backfire

When rebound is so large that it increases energy consumption beyond that which was the case before the efficiency improvement, it is called "backfire". The classic example of "backfire" is the steady improvement of steam engine efficiency in the nineteenth century, which encouraged the progressively wider use of such engines, thus dramatically increasing overall fuel consumption. Theoretically, backfire can also occur in domestic situations, a key historical example being lighting, where lighting costs in 2000 had fallen to 1/3000th of the costs in 1800 but the per capita use rose 6500-fold.[2]

2 Peter Pearson, "Past and Prospective Energy Transitions in the UK" (2010). Peter Pearson, http://www.eprg.group.cam.ac.uk/wp-content/uploads/2009/10/Peter-Pearson.pdf.

2. Summary

1. The UK's energy and climate change policies will have major impacts on the *price* (p/kWh) of electricity and gas in 2020.
2. The Department of Energy and Climate Change (DECC) estimates that the impacts on electricity prices in 2020 will be + 27% for domestic households and + 34% for medium sized businesses.
3. DECC's estimates for gas prices are + 7% for domestic households and + 11% for medium sized businesses.
4. In the 2011 Annual Energy Statement, and in a key text, *Estimated Impacts of Energy and Climate Change Policies on Energy Prices and Bills*, DECC has claimed that energy efficiency measures, the costs of which cause part of the price increase described, will protect domestic households by reducing consumption, thus preventing the price increases from being translated into increased bills.
5. The words of the then Secretary of State, the Rt. Hon. Chris Huhne, MP, in his introduction to *Estimated Impacts* are representative of the department's position:

   A net saving on average from the policies on household energy bills is expected from around 2013 and, over the remaining lifetime of this parliament (2012-2015), households are estimated to be saving on average on their energy bills compared with what they would have had to pay if we did not pursue these policies. By 2020, households are estimated to be spending, on average, 7% less to heat and power their homes compared to what they would be paying in the absence of policies.[3]

6. In addressing Parliament Mr Huhne said:

   By 2020, we expect household bills to be 7% – or £94 – lower than they would otherwise be without our policies.

   Moreover, bills will be lower during this Parliament. Britain's homes will be cheaper to heat and to light than if we did nothing, in this Parliament and in the longer term.[4]

7. However, decoding of the charts and tables in DECC's *Estimated Impacts* reveals that these claims are misleading since averaged figures are inappropriate in this case.
8. Specifically, calculations on data in *Estimated Impacts* shows that **DECC is aware that in 2020:**
   - **65% of all households (17 million households) will have higher bills as the result of the net impact of its energy and climate change policies;**
   - **Only 35% of households will have lower bills.**
9. **The average of these two effects, as used by DECC, conceals the distributional impact on households.**[5]
10. Importantly, DECC's data shows that **65% of UK households will be net losers from its policies *even if all the energy efficiency policies work exactly as described in the Government's plans*, *and costs of the climate change policies are correctly estimated***. In fact there is every reason to suppose that the efficiency measures will not live up to these expectations and that costs have been understated.
11. In fact there is every reason to suppose that the efficiency measures will not live up to these expectations.

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3 *Estimated Impacts* (2011), 3.

4 *Hansard*, 23 November 2011, Columns 300–301. http://www. publications. parliament. uk/pa/cm201011/cmhansrd/cm111123/debtext/111123-0001. htm

5 We detect other faults in DECC's presentation of its data, including: insufficient disclosure of base data to permit independent validation of all charts; over-rounding (in the energy price tables some costs below £1/MWh are represented by 0); unhelpful aggregation of some costs in tables inhibiting independent validation of the logic and calculations.

12. The government's energy saving policies may be divided into "universal" policies expected to benefit all households, and "selective" policies that apply only to some households.

13. The "universal" measures applying to all households, winners and losers alike, are:
    - Reductions in the wholesale price of electricity resulting from the Renewables Obligation and the Energy Market Reform;
    - Smart Meters and Better Billing Reform; and
    - The Products Policy (energy efficiency improvements in domestic appliances).

14. DECC's data shows that households that *only* benefit from the universal policies (i.e. 65% of all households) are expected to see increases in their bills of about £47.

15. Put another way, only those households that are beneficiaries of at least one of the following "selective" measures (35% of all households) can expect to see reductions in their bills, according to DECC's own estimates:
    - Warm Home Discount rebate;
    - Energy efficiency measures under the Green Deal, the Energy Company Obligation (ECO), the Carbon Emissions Reductions Target (CERT), CERT Extension, and the Energy Efficiency Commitment; and
    - Small scale Feed-in Tariff (FiT) generation.

16. However, all households, winners and losers alike, are exposed to underperformance of the energy saving policy measures. Thus, **if the various energy efficiency policies fail to perform as expected, the winners will be fewer and will tend to benefit less; and the losers will be more numerous and the increase in their bills will be greater.**

17. If we assume, as is not unlikely, that the universal policies underperform by 50%, then households only receiving those measures will see bill increases of about £145.

18. Similarly, all households are exposed to the underestimation of costs of the climate change policies. Some of the costs are based on little or no direct empirical data. For example, costs incurred by energy suppliers and charged to consumers in delivering Government's energy efficiency agenda are not divulged by the energy suppliers. Consequently, there is no data available to validate future costs, nor is it possible to know how the costs are distributed across the consumer base.

19. Analysis of DECC's data reveals heavy dependency on the Products Policy to mitigate the bill effects of price rises due to energy and climate policies, the hoped-for benefits from the Products Policy being equal to well over 50% of the costs of the energy and climate policies to households.

20. Unfortunately, there must be reasonable doubts with regard to the reality of benefits from the Products Policy, not least because **in putting a monetary value on the electricity savings attributed to the Products Policy, the *Estimated Impacts* document uses a price per kWh some 25% greater than that used to value the costs of green policies.** Such a calculation is likely to overvalue Products Policy savings. Furthermore, **DECC consumer costs assumptions for 2020 rely on an average saving of £158 per household attributable to the Products Policy which entails an implausible reduction in household electricity usage of about 27%**, through improved performance of electrical appliances. **In fact electricity consumption in the household sector in EU-27 grew by 40% in the years 1990 to 2008,** a trend explained by rising incomes, higher living standards, a shift towards smaller households and larger dwellings and a growing demand for electrical appliances.

21. The reductions anticipated by DECC lack plausibility in this historical context, where improvements in the efficiency of electrical products were to a large extent offset by increases in use, numbers and size of large appliances, as well as a growing number of smaller appliances such as videos and computers.[6]

22. The *Estimated Impacts* document assumes total domestic electricity savings from improved efficiency of appliances of approximately 25 TWh in 2020. However, a DEFRA response to a Parliamentary Question indicates that **33% of that quantity is for measures that have not yet been agreed with the EU, and should be regarded as uncertain**. In addition, the estimated UK domestic savings used in the *Estimated Impacts* report represent an implausible fraction (7%) of the total savings of electricity used in all sectors across the entire EU. The EU Products Policies on which DECC are relying are taking longer to implement than anticipated, and although primary legislation has been in place since 2005, the mandatory energy improvements for the first product group (domestic lighting) only started to take effect in late 2009. Such delays undermine confidence that the Products Policy could deliver the savings required by DECC, even if those savings are real.

23. As a result of slow deployment, the EU's recent (April 2012) evaluation of progress towards the estimated 2020 savings had insufficient data to reach any conclusions. In view of this, DECC's expectations for the Products Policy are unverifiable aspirations.

24. A similar lack of data results from the fact that there has been only limited independent testing of electrical appliances on the market to check compliance with the new EU standards. Nevertheless, where testing has occurred the evidence suggests significant non-compliance with standards. For example, of eight washing machines tested by the National Measurement Office (NMO) half failed to reach the claimed energy efficiency standard. Following a test of fridges and freezers the NMO prosecuted one company for labeling as A-rated a chest freezer whose performance significantly failed to meet that rating.

25. Even assuming wide adoption and compliance with standards, there is no guarantee that the public will necessarily use the appliances on the reference settings assumed. We have anecdotal evidence that a new A++ rated dishwasher is deemed to be ineffective at washing and drying on the energy saving mode, so is routinely operated in the mode that would be rated F.

26. There is also a significant risk of underperformance from the energy efficiency measures resulting from the Green Deal, and other programs listed above, with, for example, the difficulties of retrofitting effective insulation measures into older houses being well documented. Furthermore, even when these measures work, consumers may prefer to increase their comfort, thus reducing the saving anticipated ("rebound", as defined in our introduction).

27. Overall, the literature on energy efficiency reveals that too little is known about the real-world effects of energy efficiency to assume that it will shield households against rising energy costs, and DECC should not have made this assumption.

28. A review of the historical record on government's attempts to drive conservation and energy efficiency measures in the United Kingdom shows that these have never lived up to expectations, and we see no reason for thinking that they will work any better in the future. Spontaneous adoption in response to better information, improved technology and rising prices seems to offer a better option, and paradoxical though it may seem, government might be best advised to avoid driving energy efficiency, except through reductions in VAT.

29. In summary, the Department of Energy and Climate Change **has made unrealistic assumptions about the use of energy efficiency measures to offset the costs to households,** but ***even on those optimistic assumptions 65% of households will still be net losers.***

6 European Environment Agency, "Is electricity consumption decreasing in the European household sector?" (8 August 2011). See: http://www. eea. europa. eu/data-and-maps/indicators/final-electricity-consumption-by-sector/final-electricity-consumption-by-sector-2#toc-1

30. Unfortunately, **it is likely that the energy efficiency policies will fail to deliver the savings expected by government, principally due to poor uptake or performance (shortfall)**, but also due to rebound and even backfire.

31. Consequently, we see little reason for believing that UK households or the wider economy have been shielded from the very high costs of the current energy and climate change policies.

32. Furthermore, we note that in assessing its policies **DECC has focused on direct household bill impacts to the exclusion of indirect impacts through cost of living and downward pressure on household incomes and employment rates** resulting in major increases in energy prices to businesses that provide goods and services to those households, and employment to household members.

33. **Lastly, we note with regret that DECC's *Estimated Impacts* discussion of the impacts of its climate change policies lacks candour in the presentation of its results, and fails to disclose important aspects of the methodology and base data.**

3. Recommendations

34. Last year's *Annual Energy Statement*, and in particular the *Estimated Impacts of Energy and Climate Change Policies on Energy Prices and Bills* (2011) **misled the public with regard to the character of the impacts on UK households**. The current Secretary of State for the Department of Energy and Climate Change **should correct the parliamentary record, and issue a statement of clarification for the public.**

35. The manifest failures of statistical propriety and methodological clarity in *Estimated Impacts* (2011) suggest that **DECC is not the appropriate body to undertake assessment of the impacts of its own policies.**

36. Instead, we suggest that **the Office of National Statistics (ONS), which is both objective and in possession of the necessary expertise, should validate DECC's estimated price impacts and then prepare a comprehensive and transparent assessment of the economic impact of those price effects**.

37. Where levies are paid by consumers to energy suppliers via bills in order to deliver public policy **it should be a legal requirement that regular reporting of detailed and verifiable data on the costs to consumers of delivered policy measures is made publically available** so that costs of the policies can be independently and regularly verified, and value for money assessed.

38. Government should improve information available to householders on their energy bills related to energy policies, energy costs and potential energy efficiency savings. Bills should list the costs imposed on the household by environmental policies.

4. Energy and Climate Policy Cost Impacts in 2020

Price Effects

The government's climate change and energy policies will have significant effects on energy prices to both domestic and industrial and commercial consumers. The following tables summarise DECC's own statements on these price effects for domestic households.

Table 1: *Estimated impact of energy and climate policies on average household gas prices. Source: DECC.*[7]

£/MWh (Real 2010 prices)	*2011*	*2020*	*2030*
Estimated average price without policies	£39	£44	£46
Estimated average price with policies	£41	£47	£46
Percentage impact (on baseline cost)	+5%	+7%	0%

Table 2: *Estimated impact of energy and climate policies on average household electricity prices. Source: DECC.*[8]

£/MWh (Real 2010 prices)	*2011*	*2020*	*2030*
Estimated average price without policies	£130	£144	£157
Estimated average price with policies	£149	£183	£201
Percentage impact (on baseline cost)	+15%	+27%	+28%

39. In relation to the electricity price impacts it should be noted that the Department assumes that the adoption of renewables will have market effects (referred to as "merit order" effects) that will cause reductions of about £5/MWh in the wholesale price. This is debatable, and if it is not realized in practice the price impact in 2020 would be + 31%.

40. Furthermore, there is reasonable ground for believing that even if low marginal cost generators such as wind or solar drive down wholesale market prices, the additional system costs caused by uncontrollable generation will more than outweigh this effect. DECC does not discuss this matter.

41. While the impact of policies on the price of gas to domestic households is moderate, **energy and climate policies will be responsible for major increases in the retail price of electricity. At present, policies increase electricity prices by 15%, but in 2020 will be responsible for increasing prices by 27%.**

42. DECC's own data suggests that these price increases would result in £260 being added to the average non-Green Deal household combined gas and electricity bill of £1,379 in 2020, giving a total bill of £1,639, an increase of 20%.[9] (Green Deal households would see an additional charge of £20 a year, according to DECC's data.)

43. DECC's own data also suggests that the increase in the price of electricity arising from these policies would add about £150 to the annual electricity bill of £644 in 2020, an increase of well over 20%.[10]

44. Price impacts on medium sized businesses are still more significant, as the following tables show:

7 DECC, *Estimated Impacts* (2011), 63

8 DECC, *Estimated Impacts* (2011), 64.

9 See DECC infographic: http://www. decc. gov. uk/en/content/cms/infographics/household_bill/household_bill. aspx. Note that the cost of the Green Deal loan repayment has been subtracted from the infographic's £280 figure.

10 Calculated from DECC, *Estimated Impacts* (2011), 68.

Table 3: *Estimated impact of energy and climate policies on average retail gas prices to medium-sized business users. Source DECC.*[11]

£/MWh (Real 2010 prices)	*2011*	*2020*	*2030*
Estimated average price without policies	£31	£36	£38
Estimated average price with policies	£35	£39	£41
Percentage impact	+12%	+11%	+10%

Table 4: *Estimated impact of energy and climate policies on average retail electricity prices to medium-sized business users. Source: DECC.*[12]

£/MWh (Real 2010 prices)	*2011*	*2020*	*2030*
Estimated average price without policies	£98	£109	£114
Estimated average price with policies	£119	£145	£165
Percentage impact	+22%	+34%	+45%

45. While the impacts of policies on gas prices are significant, **the impact of energy and climate change policies on electricity prices to medium sized businesses is very high.**

46. These will have an indirect impact on domestic households through increases in the cost of living, as industrial and commercial consumers pass on their increased costs in the prices of goods and services purchased by households.

47. DECC's *Estimated Impacts* is narrowly focused on direct bill impacts, and neglects to consider indirect impacts on cost of living.

48. By government's own admission its offsetting policies will only go some way to mitigating the impact of cost-imposing policies, with an average electricity bill paid by a medium-sized business user rising by some 25% even after major savings due to energy efficiency measures.[13] The pass-through effect on cost of living is unlikely to be negligible.

49. Thus, even if government is correct in its assumptions with regard to the benevolent effects of efficiency measures on household energy bills, there is a significant potential for compensating increases in cost of living that may result in a net loss of standard of living.

50. Any thorough assessment of the impact of energy and climate change policies should engage with this matter, and while we recognize that assessing this impact is complex and probably requires commercially confidential information, the government is almost certainly in a better position to obtain relevant data than other parties.

51. In addition, the impact of rising prices to businesses is likely to cause a downward pressure on wages and levels of employment. Since, as DECC itself notes, UK businesses have low energy costs in comparison with most of the EU 15,[14] this has probably helped to offset the high cost of labour and other overheads, particularly in relation to industrial competitors.

52. Even with this advantage, UK businesses face fierce competition internationally, and a significant increase in energy prices and resulting costs may be difficult to absorb without compensating reductions in labour costs.

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11 DECC, *Estimated Impacts* (2011), 64.

12 DECC, *Estimated Impacts* (2011), 65.

13 DECC, *Estimated Impacts* (2011), 70.

14 DECC writes: "Business users of energy in the UK have faced the lowest gas prices, on average, in the EU 15 over the past few years and electricity prices that are around the EU 15 median." See http://www. decc. gov. uk/en/content/cms/meeting_energy/aes/impacts/impacts. aspx#

53. Thus, there is reasonable ground for concern that in addition to direct (energy bill) and indirect (cost of living) impacts, policies will simultaneously cause a reduction in household income, through reduced wages and employment rates. This does not appear to have been considered by DECC in the assessment of the energy and climate policy impacts.

Energy Efficiency and Bill Impacts

54. The core of DECC's message in *Estimated Impacts* is that the average effect on households of all its policies taken together is positive, in other words that the average household will be better off than it would have been without the policies. To quote the then Secretary of State's introduction:

> *A net saving on average from the policies on household energy bills is expected from around 2013 and, over the remaining lifetime of this parliament (2012–2015), households are estimated to be saving on average on their energy bills compared with what they would have had to pay if we did not pursue these policies. By 2020, households are estimated to be spending, on average, 7% less to heat and power their homes compared to what they would be paying in the absence of policies.*[15]

55. Most readers looking over the Secretary of State's remarks will identify, quite understandably, with the average household and infer that their own household will be better off in 2020 because of the policies.

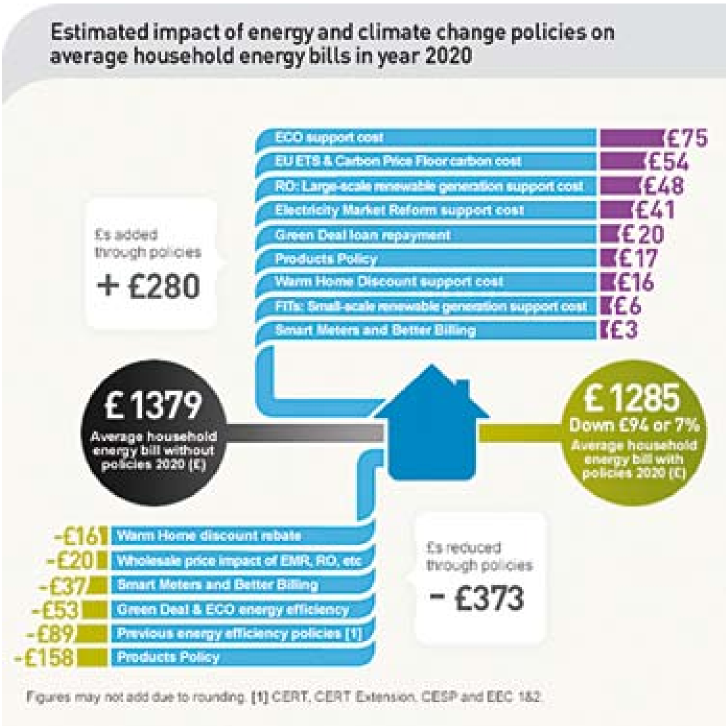

Figure 1: DECC's Estimate of the Impact of Energy and Climate Change Policies on Average Household Energy Bills in the Year 2020. Source: DECC (2011).[16]

56. To summarise, the headline message of the 2011 *Annual Energy Statement* of the Department of Energy and Climate Change (DECC) suggests that the net impact of its policies will be to reduce the average household energy bill in 2020 by £94, or 7%.

57. DECC suggests that cost imposing policies, such as the Renewables Obligation and the EU Emissions Trading Scheme (ETS), will be more than offset by policies intended to improve energy efficiency and deliver energy conservation, such as the Green Deal, the Carbon Emissions Reduction Target, and the

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15 *Estimated Impacts* (2011), 3.

16 Available at http://www. decc. gov. uk/en/content/cms/infographics/household_bill/household_bill. aspx. For further comments and criticisms of this infographic see paragraph 243–5 below.

Products Policy, as can be seen in the infographic on the preceding page, from DECC's *Annual Energy Statement* (2011).

58. A reader of the main text might reach similar conclusions from DECC charts such as the following, in *Estimated Impacts*:

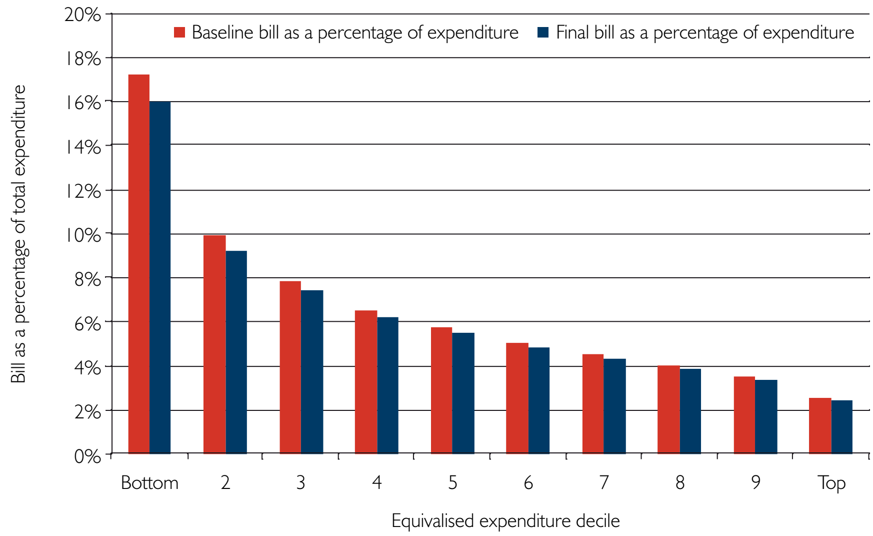

Figure 2: Energy bill as a percentage of expenditure in 2020, with and without energy and climate change policies across expenditure deciles. Source: DECC.[17]

59. An intuitive reading of this chart suggests that the impact of policies is expected to be benign, with average households saving across the entire population, and with the largest savings applying to those in the lower expenditure deciles. In other words, that those who are in all probability least able to afford extras on their bill, will see the biggest reductions.

60. However, commenting on this chart DECC itself concedes that it "*does not tell the full story as the impact on households will depend on whether they receive or take out policy measures*".[18] In fact, there are some policy measures that DECC regards as inevitably applying to all households, namely: a) the wholesale price reducing impact of the Electricity Market Reform and the Renewables Obligation; b) Smart Meters and Better Billing; and c) the Products Policy. On the other hand there are a range of policies, for example the Green Deal, that will only benefit subsets of all households, because they require action on the part of the household.

61. We refer to the first of these groups as the "universal" policies, and to the second as the "selective" policies.

62. To illustrate this distinction, *Estimated Impacts* presents the following chart, which separates those households benefiting from at least one of the selective measures from those households who do not benefit from them. The measures listed by DECC are the Carbon Emissions Reduction Target (CERT), CERT Extension, the Community Energy Savings Plan (CESP), the Green Deal, the Energy Company Obligation, the small scale Feed-in Tariff (FiT), and the Warm Homes Discount (WHD). (The inclusion of the FiT here is puzzling, since it does not appear in the infographic reproduced above.)

63. For the avoidance of doubt, it should be noted that all households considered in this chart are regarded as benefitting from the Products Policy, Smart Meters and Better Billing, and the whole price impact of the RO/EMR.

17 *Estimated Impacts* (2011), 31.
18 *Esimated Impacts* (2011), 32.

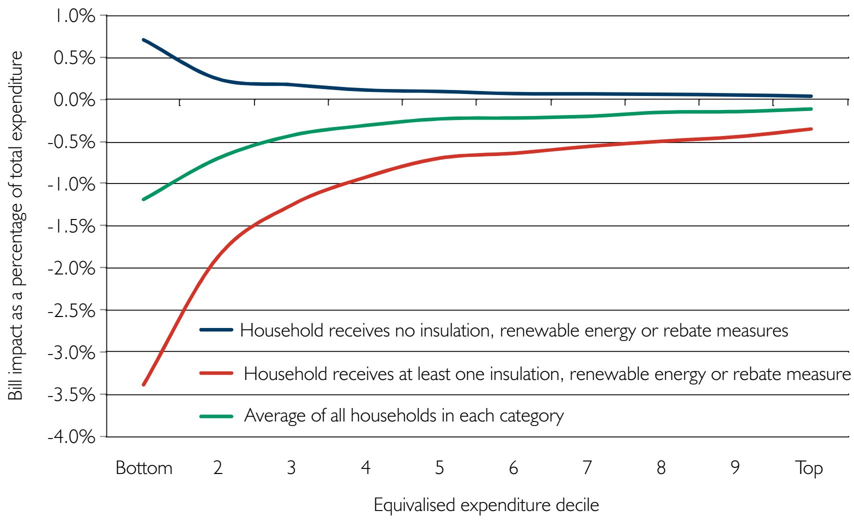

Figure 3: The effect of receiving an insulation or renewable energy measure or a rebate on the impact of policies on household energy bills as a percentage of expenditure in 2020, across expenditure deciles. Source: DECC 2011.[19]

64. The chart thus divides UK households into two categories:

a) Households that benefit from *at least one of the above selective measures* (the red line), **and the universal policies**.

b) Households that benefit from none of the selective policies (the blue line), and benefit only from the universal policies.

65. As will be immediately evident, those receiving at least one selective measure see a decline in their bills (red line) as a proportion of expenditure, and those who do not receive a selective measure see an increase (blue line).

66. The green line represents the average of these two figures, and suggests an average saving over all households.

67. However, the chart tells us nothing about the distribution of the UK's households into the two categories, the winners and the losers, and DECC does not provide a clear statement on this point. Nevertheless, a subsequent paragraph provides enough information to allow us to make those calculations.

68. In paragraph 56 DECC writes:

> *Although those in the bottom three deciles that do not receive measures will face the largest increase in their bill as a proportion of expenditure, the modeling suggests that around 40% of the households in the bottom three deciles could benefit from at least one of these measures. This is greater than in other deciles, where just over a third of households are expected to benefit.*[20]

69. The lower three deciles contain, by definition, 30% of all households, and since DECC tells us that the red line covering those three deciles refers to 40% of that quantity, we can calculate that the red line covering the lowest three deciles refers to 0.3 x 0.4 = 12% of all households.

70. Similarly, the red line covering the other seven deciles contains, according to DECC, just over 33% of households, so we can calculate that this part of the red line refers to 0.7 x 0.33 = 23% of all households.

71. Thus the red line refers to 35% of all households, and it follows therefore that the blue line refers to the remainder, or 65% of all households.

19 DECC, *Estimated Impacts* (2011), 32.
20 DECC, *Estimated Impacts* (2011), 33.

72. Four further conclusions follow:
- DECC expects only 35% of all households to receive a measure from at least one of the following: CERT, CERT Extension, CESP, Green Deal, FiT, and WHD.
- DECC expects that only those households benefitting from at least one of the above measures will see a net reduction in their bills.
- **DECC expects only 35% of all households to see a *net reduction* in their bills as a result of policies.**
- **DECC expects 65% of all households to see a *net increase* in their bills as a result of policies.**

73. These are extraordinary findings, and at variance with the Secretary of State's introduction to *Estimated Impacts*, with his statement to the House of Commons, and with the publicity surrounding the publication of the 2011 *Annual Energy Statement*.

74. It is clear that the use of an average impact, even if weighted (as the green line may be), is extremely misleading and should not have been used in a case when the distribution is strongly skewed. This is an elementary statistical error.

75. Most reasonable people shown DECC's statements would tend to regard the "average" impact as being representative of the likely impact on their own household, and conclude that it would be around a 7% saving, perhaps a bit more, perhaps a bit less. But, as we have seen, this would be quite wrong. The overwhelming majority of households would be net losers.

76. Insight into the likely impact on the losing households can be gained by recalculation from data in DECC's infographic, reproduced above, and the price and bill impact tables in Annexes E and F to *Estimated Impacts*.

77. Unfortunately, DECC's *Estimated Impacts* is poorly referenced and does not provide adequate tables of base data. Indeed, we note that some of the price tables in Annex E assign the value zero (0) to cells where logic and the column totals show that there must be a price effect, indicating that the data has been over-rounded. However, from the data that DECC has published, and accepting that the lack of precision of the source data available leads to some rounding errors, we can with some degree of confidence infer those missing values and construct a table of the price and cost effects that underlie DECC's infographic and its price and cost bill impact tables.

78. This table and a graphical representation of the data follow on page 15.

79. It is immediately evident that the costs of the energy saving measures introduced under the Energy Company Obligation (ECO) are very high (£38 on gas, £37 on electricity), even in comparison with such notoriously costly policies as the Renewables Obligation (RO).

80. The table also brings into prominence the fact that the bulk of savings assumed by DECC are in relation to electricity bills, which provide £318 of savings out of a total of £375, or 85%. This is strangely unbalanced, and appears both implausible and arbitrary.

81. In addition, the bulk of those electricity savings comes from one policy set alone, the Products Policy, which is expected to provide £158 of £318 of savings. This narrow focus suggests that the government's proposals for protecting consumers against policy-induced bill increases are fragile and sensitive to underperformance in only one policy area.

82. Additional calculations from this table suggest a worst case scenario in which the policy costs arrive in full, but the savings do not. In such a case the electricity bill would rise by about £200, or over 30%, and the gas bill would rise by £47, or 6%. The total increase would be about £265, or 19% of DECC's assumed bill without policies.

Table 5: *Breakdown of DECC's Assumptions of Costs and Impacts on the Average Gas and Electricity Bill in 2020. Source: REF inferences from DECC Data.*

Policy	Impact on Electricity Bill	Impact on Gas Bill	Total Energy Impacts
ECO Support Cost	£37	£38	£75
EU ETS	£49		£49
Renewables Obligation	£48		£48
Electricity Market Reform	£41		£41
Green Deal repayment	£20		£20
Products Policy Heat Replacement Cost		£17	£17
WHD support	£9	£8	£17
Carbon Price Floor	£6		£6
Feed-in Tariff	£6		£6
Smart Meters	£1	£1	£2
Better Billing	£1	£0	£1
CESP	-£1		-£1
Better Billing	-£3	-£3	-£5
Warm Home Discount	-£17		-£17
Merit Order	-£20		-£20
CERT Extension	-£5	-£20	-£25
Smart Meters	-£22	-£11	-£32
ECO & Green Deal	-£48	-£5	-£53
CERT & EEC	-£44	-£19	-£63
Products Policy	-£158		-£158
Without Policies	**£644**	**£735**	**£1,379**
Costs	£218	£64	£282
Savings	-£318	-£57	-£375
With Policies	**£543**	**£742**	**£1,285**

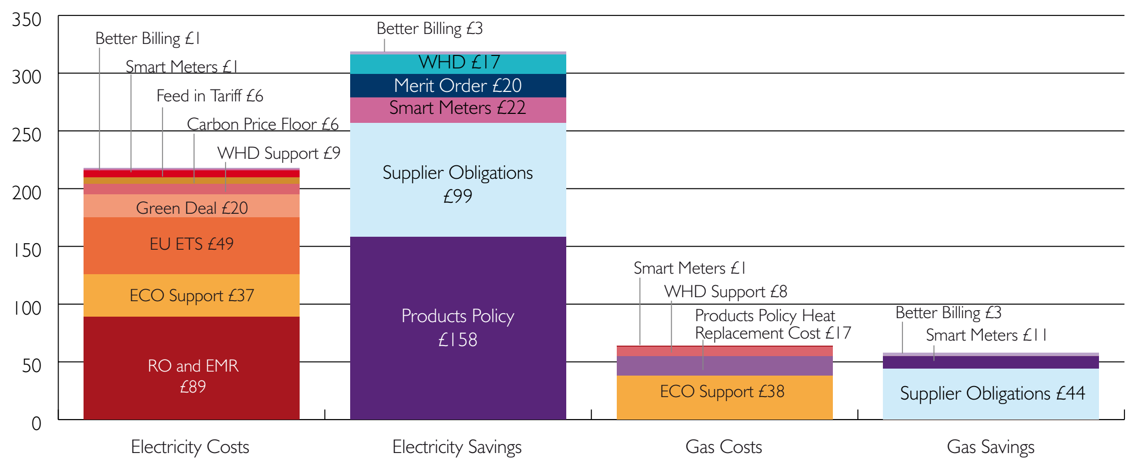

Figure 4: DECC's estimated average costs and savings on domestic electricity and gas bills in 2020 as a results of climate change policies. Source: Table 5.

83. However, it should be noted that this scenario assumes that DECC's policy cost estimates are correct. There must be very considerable doubt over this point. Even the government's own advisors have indicated that hard cost data for supplier obligations, such as the ECO, is not available owing to commercial sensitivities of the suppliers.[21]

84. It should also be noted that DECC's assumed bill without policies is grounded in assumptions with regard to fossil fuel prices that may well be wrong. Should fossil prices fall significantly up to and beyond 2020, as they might, these policy costs will appear proportionately very much more expensive. It has sometimes been observed that the UK's current policies are a bet on the price of gas in ten years' time, and the table underlines this point.

85. In our analysis above we have shown that DECC's own charts and statements indicate that the department is aware that 65% of households will actually see increased bills in 2020, because the policies (which we call the "universal" policies, such as Smart Meters and Better Billing) from which they benefit are not sufficient to completely offset the costs of all policies. The table above allows us to gain some insight into the nature of that impact, and by removing all the "selective" benefits that apply only to the 35% of households who see a decrease in their bills, we can calculate that **on the government's own view roughly 65% of households will see an energy bill increase of about £47 a year, all of that additional cost falling on the gas bill**.

86. We can conclude that in effect the 65% who see higher bills are subsidising the winning households by paying for the cost of the Energy Company Obligation (and other measures) even though they do not benefit from it.

87. In our view, the government's expectations for the universal policies, particularly the Products Policy, are optimistic (a point developed at length below). **If we suppose, for the sake of argument, that the universal policies all underperform by 50%, which we think is not at all unlikely, the bill increases faced by the losing households would be around £145**, as can be seen in the figure below.

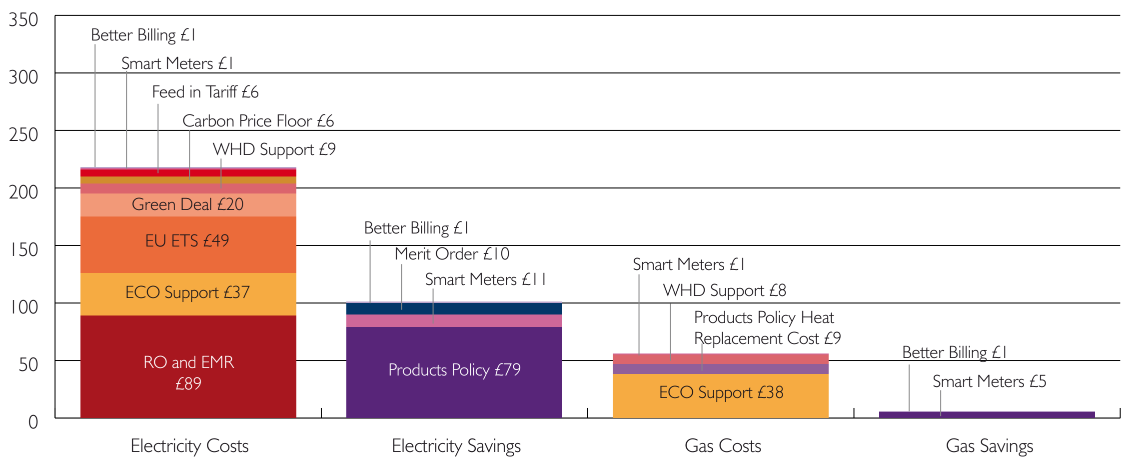

Figure 5: Estimated average costs and savings for the majority of domestic electricity and gas bills in 2020 as a results of climate change policies assuming 50% underperformance of universal policies. Source: REF calculations on DECC data.

88. On the basis of this table we therefore infer that **on DECC's own assumptions 65% of all households in 2020 will see energy bill increases of around £46 a year, even assuming that the energy efficiency policies perform to plan.**

89. **More probably, the policies will not work and these households, the vast majority, will see bill increases of around £145.** If government's estimates of policy costs are underestimates the costs will be even higher.

21 See Evaluation of the Delivery and Uptake of the Carbon Emissions Reduction Target, **http://www.decc.gov.uk/en/content/cms/funding/funding_ops/cert/cert.aspx**

90. In the light of these findings many will probably conclude that in recommending the *Annual Energy Statement* to the House of Commons the then Secretary of State, the Rt Hon Chris Huhne MP, misled the House. He remarked:

> *We believe that the policies we have introduced will deliver the best value for consumers, as we move towards a cleaner energy future.*
>
> *However, as we embark on the transformation of our energy system, we must take people with us. That is why I am today publishing an assessment of prices and bills, and the impact of our policies.*
>
> *Overall, we anticipate that rising world gas prices will push up bills for both gas and electricity, but our policies will moderate that rise. By 2020, we expect household bills to be 7% – or £94 – lower than they would otherwise be without our policies.*
>
> *Moreover, bills will be lower during this Parliament. Britain's homes will be cheaper to heat and to light than if we did nothing, in this Parliament and in the longer term.*[22]

91. Instead, the Secretary of State should have observed that on the Department's assumptions the net effect of policies was to mitigate the increase in bills for 65% of households, but to reduce bills for only 35% of households.

92. It seems to the present authors that the current Secretary of State must not only ensure that misleading representations such as those found in last year's *Annual Energy Statement* do not recur in this year's statement, but also that he must make a statement to Parliament correcting previous accounts of the Department's own modeling of impacts.

93. To restore the credibility of *Estimated Impacts*, and perhaps of other aspects of the *Annual Energy Statement*, we recommend that in future the Office of National Statistics (ONS) should be entrusted with producing a comprehensive assessment of the economic impact of DECC's policies, rather than the department itself.

94. Detailed examination of the distribution of the savings and increases across the population of households would be particularly valuable, but DECC's *Estimated Impacts* does not present tables of base data relating to the department's assumptions regarding impacts across the expenditure deciles.

95. We note that DECC should have presented its findings in very much clearer terms, and given full base data with regard to equivalised expenditure; the charted data provided is inadequate for a proper assessment.

Implications for Cost of Living

96. The government's climate change and energy policies will have significant effects on prices for both domestic and industrial and commercial consumers.

97. These price increases have direct impacts on households via their energy bills, but also indirect impacts through increases in cost of living, as industrial and commercial consumers pass on their increased costs in the prices of goods and services purchased by households, and also as public sector costs require increased levels of taxation to support them.

98. We find that DECC's *Estimated Impacts of Energy and Climate Change Policies on Energy Prices and Bills*, which forms part of the *Annual Energy Statement*, is narrowly focused on direct bill impacts, and neglects to consider indirect impacts on cost of living and general taxation. This defect should be rectified in future publications.

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22 *Hansard*, 23 November 2011, Columns 300–301. http://www. publications. parliament. uk/pa/cm201011/cmhansrd/cm111123/debtext/111123-0001. htm

99. DECC justifies its narrow focus on the grounds that, according the *Annual Business Survey*, energy and water (the costs being aggregated in the survey) comprised 2.7% of overall manufacturing costs (total purchases plus employment costs) in 2009,[23] and are therefore of only minor significance.

100. However, there is a case for examining energy as a percentage of total purchase costs, on the grounds that a business may find it easier to adjust wages (a cost under its control) than other inputs to the business, and that therefore an increase in energy costs may exert a downward pressure on wages and employment levels.

101. Table 6 below, drawn from the *Annual Business Survey* data, calculates energy and water expenditure as a percentage of total purchases for the various sectors studied.

Table 6: *Cost of energy and water purchases as a percentage of total purchases in 2010. Source: Office of National Statistics, Annual Business Survey 2011.*

Industry	*Total Purchases (£m)*	*Cost of Energy and Water (£m)*	*Energy as % of total purchases*
Mining and quarrying	23,924	828	3.5%
Manufacturing	316,022	9,878	3.1%
Construction	112,714	2,874	2.5%
Retail trade (except motorcycles)	261,830	3,353	1.3%
Transport and Storage	77,119	14,423	18.7%
Accommodation and Food Services	36,576	2,277	6.2%
Information and Communication	99,886	1,596	1.6%
Real Estate activities	17,160	600	3.5%
Professional, scientific and technical activities	86,075	1,994	2.3%
Administration and support services	77,112	2,038	2.6%
Education	18,462	851	4.6%
Human Health and Social Work	16,572	1,382	8.3%
Arts, Entertainment, and Recreation	73,082	904	1.2%
Other service activities	16,748	900	5.4%
Wholesale trade except motor vehicles	668,629	3,419	0.5%
Water supply, sewage, Waste Management	14,288	1,218	8.5%
Electricity, gas, steam, air conditioning supply	71,860	6,201	8.6%
Agriculture, Forestry, and Fishing	3,288	172	5.2%

102. Setting aside the special case of transport, energy and water is on average about 4% of total purchases. However, certain sectors emerge as having rather higher proportional costs, notably the hospitality industry (accommodation and food services), at 6.2% and human health and social work, at 8.3%.

23 DECC, *Estimated Impacts* (2011), 3, 22. See http://www. decc. gov. uk/assets/decc/11/about-us/economics-social-research/3593-estimated-impacts-of-our-policies-on-energy-prices. pdf

103. We are aware that there is some concern as to the quality of the data reported in the *Annual Business Survey,* and the aggregation of water and energy costs certainly clouds the picture, but there is sufficient information here to give cause for concern, and to undermine confidence in DECC's dismissal of this topic.

104. Furthermore, DECC focuses on the cost of energy (and water) in isolation, without drawing attention to the fact that energy costs form a proportion of all other purchases, and increases in energy costs will increase the cost of these other non-energy inputs.

105. DECC's argument runs as follows:

> *For most businesses, direct energy costs are a relatively small proportion of total costs. For example, in 2009, purchases of energy and water accounted for around 2.7% of total costs for the UK manufacturing sector as a whole. This means that a 10% rise in direct energy costs increase total costs to the manufacturing sector by 0.27%.*[24]

106. Using DECC's estimate of climate policies impacts on the energy bill for small and medium sized businesses, quoted above, let us suppose that the energy (gas and/or electricity) bill of UK manufacturing businesses rises by 28%, and that such energy is about 3% of its total costs. Direct energy costs would rise by 0.8% of its total costs.

107. Let us suppose for the sake of argument that the energy costs of suppliers to manufacturing businesses rise in a similar way, and that, as is inevitable, they pass this through in the prices charged to the manufacturers. Thus, the non-energy purchases of manufacturing businesses will rise by a similar amount, 0.8% of total costs. Taken together, direct and indirect effects cause manufacturing to experience an increase in costs equivalent to between 1% and 2% of its total costs, a far from negligible increase.

108. This abstract and simplified example does not take into consideration the way in which non-energy costs may vary across suppliers to manufacturing, but it does show that in principle the indirect effects of energy cost increases to businesses deserve serious consideration and should not be neglected.

109. Thus, there is every reason to suppose that: a) rising energy costs as the result of policies will be passed on to households through cost of living and taxation to support public services (and it is relevant here to note the importance of energy to the health service); and b) that there may well be secondary impacts on households through reduced household incomes as businesses cut labour costs in order to absorb rising energy costs.

110. Quantifying such indirect impacts on households is a major project in itself, and beyond the scope of the current critique. It is disappointing, however, that DECC's *Estimated Impacts* makes no referenceat all to this matter.

111. In the light of the significant increases in energy prices to industrial and commercial users it is important to realize that this will encourage those with strong market bargaining positions to negotiate lower prices, thus transferring some of the policy costs to other, weaker consumers. As DECC remarks:

> *It is possible that the costs of policies are distributed in such a way that a few large users may face a smaller impact per unit of energy compared with smaller energy users. The same may also be true for households and businesses that may be more likely to switch tariffs or energy suppliers at the expense of more sticky customers. Our central assumption is that policy costs are spread evenly per unit of energy consumption across all relevant energy users. There is currently limited evidence on how retail energy suppliers' costs are spread across their users. It is possible that, owing to their bargaining power and economies of scale in the supply of energy, very large energy consumers could pay retail prices that are close to the wholesale price, with energy and climate change policies only having an impact on the energy prices they pay insofar as they affect wholesale prices or are levies imposed directly on them*

24 *Estimated Impacts* (2011), 22.

(such as the Climate Change Levy (CCL)) – with the implication being that other users face higher policy costs as a result.

112. It is curious that DECC though aware of the high probability of the uneven distribution of costs has persisted in basing its central estimates on the assumption that the Renewables Obligation is distributed evenly over all units of electricity sold, with no consumer sectors paying more proportionally than others.

113. On this "even distribution" view, if domestic households consume *36%* of all kWhs sold, then they pay 36% per cent of the Renewables Obligation costs.

114. However, as DECC grants, due to the market power of larger business consumers they are able to buy much closer to the wholesale price than a domestic consumer, and it follows, therefore, that domestic consumers carry a larger proportional burden of the cost of measures such as the Renewables Obligation.

115. Data in DECC's *Estimated Impacts* seems to confirm this point. Tables E2, E4 and E6 show the price impact per MWh of the various policies for domestic households, medium sized business consumers, and energy intensive users.[25] In the following table we have extracted the Renewables Obligation prices for 2011 and 2020 for these groups, and calculated the differential burden:

Table 7: *Price impacts of Renewables Obligation, £/MWh*

Sector	*2011*	*2020*
Domestic	5	11
Medium Sized Business	4	10
Energy Intensive	0–4	0–10

116. These are rounded figures, but it appears that the burden of the Renewables Obligation is not evenly spread over all units sold, with the impact on domestic consumers being about 25% more per unit in 2011, according to these figures, than for medium-sized business consumers.

117. We think it fair to conclude that domestic consumers over the period 2011 to 2020 will be paying a larger proportional share of the Renewables Obligation costs than other consumers. To put this into clear terms, whereas domestic consumers account for about 36% of consumption of electricity,[26] they will probably be paying over 40% of the costs of the Renewables Obligation.

118. Further concretization of this effect can be obtained if we take the RO cost in the calendar year 2011, of £1.5 billion, and observe that if the costs were spread evenly over all units sold, domestic consumers would be paying about £540 million of that cost, whereas on the assumptions described above they are probably paying closer to £620 million, or a difference between £20.77 per household and £23.82 per household (assuming 26 million households). To put this in another way, 13% of the RO cost impact on domestic households at present results from the uneven distribution of those costs over the various consumer sectors.

119. While we understand that many will feel that this is iniquitous, it is important to realize that such effects are all but inevitable with a subsidy support system that raises funds through a levy on consumer sectors with differing bargaining positions.

120. It would be wrong and probably counterproductive, in our view, to conclude that these distributional effects should be corrected by further government intrusion into the pricing structure. On the contrary, **the conclusion that we draw from the emergence of distributional effects such as those described**

25 DECC, *Estimated Impacts* (2011), 64–66.

26 DECC, *Digest of United Kingdom Energy Statistics*, Table 5. 2. Domestic consumers account for 118. 7 TWhs out of a final consumption of 328 TWhs.

above is that the concept of raising funds to subsidise renewables through a consumer levy was fundamentally mistaken.

121. Looking to the future impact of costs, we can take our own estimate of the subsidy cost of the Renewables Obligation and any successor mechanism (the Electricity Market Reform package, EMR), at about £8 billion a year in 2020,[27] and note that assuming the distributional effect above this would entail a direct bill impact on domestic households of just under £3.3 billion, or about £120 per household, assuming 28 million households. Note that this is considerably in excess of the DECC costs per household prediction of £89 for the RO and the EMR in 2020.

27 REF, *Energy Policy & Consumer Hardship* (London: 2011), 27.

5. Can We Rely on Energy Efficiency to Offset Climate Policy Costs?

122. In the previous section we have seen that even on the government's own estimates the net impact of its policies leaves 65% of households with higher energy bills than they would have been in the absence of those policies, with only 35% with lower energy bills.

123. In this section we turn to the government's cost-reducing policies themselves, and ask whether they are in fact likely to deliver the effects expected of them.

124. As noted above, if the energy efficiency policies, most notably the Green Deal, ECO, and the Products Policy do not deliver, then fewer people will see net savings on their energy bills, and those already seeing net increases will see larger increases.

125. We consider the policies in the light of three areas of risk:
   - That the energy efficiency policies will simply not work as well as expected, which we call *shortfall*.
   - That the energy efficiency policies will work reasonably well, but the energy savings realized will be less than expected because of the *rebound* effect, whereby consumers make greater use of the more efficient service.
   - That the rebound will be so large that energy consumption in relation to that service will actually increase (*backfire*).

126. We will begin by examining theoretical discussions of the rebound and backfire effects, beginning with W. S. Jevons, whose remarks on the tendency of efficiency improvements to drive increases in consumption still lie at the root of current thinking.

The Jevons Paradox

127. William Stanley Jevons had begun to despair of ever making his reputation. Works on economics and logic, published at his own expense, had not met with an enthusiastic reception. His *Pure Logic* of 1863, indeed, sold only four copies in a year.[28] In 1855, Jevons' attempt "to write on popular subjects" had been issued in *The Coal Question*; but that, too, seemed destined to sink without trace.[29] Then, on 17 April 1866, everything changed. James Stuart Mill addressed the House of Commons, drawing his arguments from Jevons' book.[30] William Gladstone followed Mill's lead in his budget speech in May, and invited Jevons to Downing Street to discuss his ideas. Gladstone and Mill had a political agenda of their own, but the subject of *The Coal Question* – the depletion of Britain's coal reserves – soon became a matter of sincere public concern.[31]

128. Newspapers dubbed the debate "the Coal Panic",[32] and a Royal Commission was established at the end of June to look into the question with the greatest urgency.[33] It is easy to see why. Jevons begins *The Coal Question* by declaring that "the Coal we happily possess in excellent quality and abundance is the Mainspring of Modern Material Civilization."[34] The nineteenth century is "the Age of Coal", and it is delusional to attribute Britain's international supremacy to anything else:

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28 R. D. Collison Black, "Jevons, William Stanley (1835–1882)", *Oxford Dictionary of National Biography* (Oxford, 2004).

29 *Papers and Correspondence of William Stanley Jevons*, ed. R. D. Collison Black (7 vols., London, 1972-81), iii, 52; cf. Michael V. White, "A Biographical Puzzle: Why did Jevons Write *The Coal Question*?", *Journal of the History of Economic Thought*, vol. 13, no. 2 (1991), 222–242.

30 *The Collected Works of John Stuart Mill, Vol. XXVIII - Public and Parliamentary Speeches Part I November 1850 - November 1868,* ed. John M. Robson and Bruce L. Kinzer (Toronto & London, 1988), 70–71.

31 Michael V. White, "Frightening the 'Landed Fogies': Parliamentary Politics and *The Coal Question*", *Utilitas*, vol. 3, no. 2 (November 1991), 289–302.

32 See, for example, *The Times*, 19 April 1866.

33 *Papers and Correspondence*, iii, 102; *W. S. Jevons: Critical Responses*, ed. Sandra J. Peart (4 vols., London, 2003), i, 359f.

34 W. Stanley Jevons, *The Coal Question* (1st ed., London, 1865), vii.

> *Coal, in truth, stands not beside but entirely above all other commodities. It is the material energy of the country – the universal aid – the factor in everything we do. With coal almost any feat is possible or easy; without it we are thrown back into the laborious poverty of early times.*[35]

129. But unfortunately a return to "laborious poverty" is unavoidable, Jevons warns, for Britain's coal is a finite resource, and it is being rapidly and inexorably depleted. He argues in detail that attempts to limit the consumption of coal or to find alternative sources of fuel are doomed to failure. Jevons concludes that the only responsible course of action is to take measures to militate against the inevitable economic decline that will follow an exhaustion of Britain's useable coal reserves. To a nation whose prosperity was indeed manifestly founded on coal, it is easy to see why this should seem, as Jevons put it, "a question of almost religious importance".[36]

130. Jevons, of course, underestimated the extent of Britain's coal fields. By the time *The Coal Question* entered its third edition in 1906, it was already clear that he was mistaken, too, in predicting that new fuels capable of replacing coal would never be discovered. But despite all this, readers have continued to return to *The Coal Question*, and to the arguments that Jevons advances in its pages. While there is an obvious parallel between "the Coal Panic" of the mid-nineteenth century and the contemporary debate concerning peak oil, this is not the primary source of Jevons' continuing salience. Rather, it is Jevons' thesis that improvements in energy efficiency increase total national energy consumption – the so-called Jevons Paradox – that has monopolized the attention of posterity.[37] Indeed, this refusal to take the easy consolation of believing that improvements in efficiency could result in energy resource conservation, marks him out from many later writers.

131. The high energy prices of 1973-1974 and 1979-1980 raised, for the first time since the mid-nineteenth century, serious questions about the economics of energy efficiency, and it was then that Jevons began to receive serious attention. Since that time, an acrimonious and important debate has raged between those who affirm the validity of the Jevons Paradox and those who deny it.[38] At present, the Jevons Paradox is invoked in opposition to those who claim energy efficiency savings can reduce our demand for energy, and thus reduce carbon emissions, without compromising economic growth. This contention is at the heart of British energy policy. But what did Jevons actually say?

132. In *The Coal Question*, Jevons engages with those of his contemporaries who urged "that the failing supply of coal will be met by new modes of using it efficiently and economically".[39] Indeed, *"it is wholly a confusion of ideas"*, he declares, *"to suppose that the economical use of fuel is equivalent to a diminished consumption. The very contrary is the truth"*.[40] Drawing on the French economist Jean Baptiste Say, Jevons goes on to argue that:

> *As a rule, new modes of economy will lead to an increase of consumption, according to a principle recognised in many parallel instances. The economy of labour effected by the introduction of new machinery, for the moment, throws labourers out of employment. But such is the increased demand for the cheapened product, that eventually the sphere of [its] employment is greatly widened…*[41]

133. In a famous passage, Jevons showed that James Watt's steam engine, though vastly more efficient than the less advanced engines it replaced, had nonetheless greatly increased Britain's consumption of

35 Ibid., viii.

36 Ibid., xix.

37 For a survey of the literature, see Blake Alcott, "Jevons' paradox", *Ecological Economics*, vol. 54 (2005), 9–21.

38 See summaries of the debate in Horace Herring, "Does energy efficiency save energy? The debate and its consequences", *Applied Energy*, no. 63 (1999), 209–226; Blake Alcott, "Historical Overview of the Jevons Paradox in the Literature", in John M. Polimeni, Kozo Mayumi, Mario Giampietro & Blake Alcott, *The Myth of Resource Efficiency: The Jevons Paradox* (2nd ed., London, 2009); and Leonard Brookes, "Energy efficiency fallacies revisited", *Energy Policy*, no. 28 (2000), 355–366.

39 Jevons, *The Coal Question*, 102.

40 Ibid., 103 (emphasis original); cf. Polimeni, Mayumi, Giampietro & Alcott, *The Myth of Resource Efficiency*, 11.

41 Ibid., 103–104.

coal by making steam power more economically attractive. Energy efficiency improvements, in other words, are experienced by the consumer as reductions in the cost of using energy.[42]

134. Since the 1980s, the Jevons Paradox has been formulated in more sophisticated terms, and it is often referred to as the "Khazzoom-Brookes postulate", after its two most influential proponents. The notion that attempts to save energy through improved energy efficiency actually result in increased energy consumption is often referred to as the "rebound effect". But the argument has not changed. Its proponents draw on a wide range of examples. In the 1980s and 1990s, Leonard Brookes and Daniel Khazzoom published influential papers that set out the Jevons Paradox and its implications for public policy. In the last decade, Smil, for instance, has observed that, despite substantial energy efficiency improvements, American motor vehicles consumed thirty-five per cent more energy in 2000 than they did in 1980.[43] Similarly, Horace Herring has shown that while the energy efficiency of British public lighting improved about twentyfold between 1920 and 2000, so much more public lighting was installed that electricity consumption per kilometre of British road has increased by twenty-five times.[44] The critics of the Jevons Paradox, on the other hand, claim that the rebound effect is, as Amory Lovins put it, "insignificant" – or, in the words of Lee Schipper and Michael Grubb, that it is "small".[45]

135. Most of the critics of the Jevons paradox, however, conflate the micro- with the macroeconomic. As Vaclav Smil writes,

> *there is no doubt that relying on devices and machines that convert fuels and electricity with higher efficiency leads to lower energy use and to savings of money at microeconomic level […] and even at mesoeconomic level, for entire industries. But […] historical evidence shows unequivocally that secular advances in energy efficiency have not led to any declines of aggregate energy consumption.*[46]

136. Nor are critiques that attempt to contradict the empirical historical record by reference to the predictions of theoretical models particularly compelling. At a national and a trans-national level, the relationship between energy intensity (the energy used to produce a unit of GDP) and energy consumption speaks for itself: as energy intensity falls (i.e. as energy efficiency increases), energy consumption increases. While in some cases other factors such as population growth certainly do contribute to increases in energy consumption, the correlation between energy intensity and energy consumption is the same even in developed countries with static or negative population growth.[47] Smil reiterates: "historical evidence is […] replete with examples demonstrating that substantial gains in […] efficiencies stimulated increases of fuel and electricity […] use that were far higher than the savings brought by these innovations".[48]

137. In a more ultimate sense, this is also a debate about human behaviour. As Brookes argues, "purchasing power released by lower expenditure on existing uses of fuel finds an outlet somewhere, and in modern industrial societies it is almost bound to be in the purchase of goods and services that require energy in their production".[49] In other words, demand for goods and services is inherently elastic. Energy saved in the manufacture of a particular good, or in the performance of a particular service, will be employed in manufacturing other goods, or in performing other services. John Stuart Mill

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42 Ibid., 104–105.

43 Vaclav Smil, *Energy at the Crossroads: Global Perspectives and Uncertainties* (Cambridge, Mass., 2003), 333.

44 Horace Herring, "The Rebound Effect, Sustainable Consumption and electronic appliances" in *Sustainability in the Information Society,* eds. Lorenz Hilty & Paul Gilgen (Marburg, 2001).

45 Amory Lovins, "Energy savings resulting from the adoption of more efficient appliances: another view", *Energy Journal*, vol. 9, no. 2 (1988), 156-7; Lee Schipper and Michael Grubb, "On the rebound? Feedback between energy intensities and energy uses in IEA countries", *Energy Policy* no. 28 (2000) 367–38.

46 Smil, *Energy at the Crossroads*, 332; cf. Polimeni, Mayumi, Giampietro & Alcott, *The Myth of Resource Efficiency*, 143.

47 See Polimeni, Mayumi, Giampietro & Alcott, *The Myth of Resource Efficiency*, 147–169 for a detailed discussion of the nature of this correlation.

48 Smil, *Energy at the Crossroads*, 337.

49 Leonard G. Brookes, "The greenhouse effect: the fallacies in the energy efficiency solution", *Energy Policy* (March, 1990), 201.

complained that "industrial improvements" were capable of "abridging labour", if only people would be content with "a stationary condition of capital and population".[50] But the historical record does not indicate such a tendency.

138. The rediscovery of Jevons' work is relatively recent, and the sophisticated discussion of rebound and backfire effects is still in its early stages, the growing literature around it being as yet largely theoretical with only a slender empirical element allowing the testing of hypotheses.

139. However, Jevons is here to stay, and the discussion in the field in which he blazed the trail is now more concerned with the depth and significance of rebound effects, than with their existence; and more focused on those areas where rebound is less probable due to relatively inelastic demand for the service made cheaper by efficiency improvements.

140. This aspect of the history of thought on the economics of energy efficiency is in itself significant when reviewing the current government's policies on this matter, and their expectations. Given a new and relatively undeveloped sector it is disappointing to find the Department of Energy and Climate Change placing such heavy reliance on the ability of efficiency improvements to deliver conservation.

141. While it is perhaps true that not all domestic energy efficiency improvements are likely to be eroded by direct rebound effects (a more efficient toaster seems unlikely to drive greater consumption of toast), it is quite conceivable that cost reductions in one area will stimulate the uptake of other energy consuming devices in another.

142. Furthermore, there are areas where straightforward rebound is conceivable, even likely, such as policies affecting domestic heating such as better insulation, and indeed DECC makes allowance for this in *Estimated Impacts* (2011),[51] writing:

> *The efficiency savings from the household measures include an 'underperformance' factor based on a review of measured versus theoretical energy savings. In addition, it is estimated that approximately 10% of the building stock have parts of their external walls that are inaccessible, reducing performance of Cavity Wall Insulation installations. In addition, a 15% comfort factor is assumed.*[52]

143. The reference cited is to Sanders and Phillipson's 2006 work, *Review of Differences between Measured and Theoretical Energy Savings for Insulation Measures* (Centre for Research on Indoor Climate and Health: Glasgow Caledonian University: December 2006).

144. It is interesting to note in passing that the "reduction" factor revealed in that study is a very striking 50%, of which comfort-taking comprises 15 percentage points, and the remainder is accounted for by underperformance or "shortfall" of the measure. DECC refers to the 15% comfort figure, but does not make explicit mention of the 35% underperformance figure, leaving it unclear whether they have actually employed this figure or some other based upon it. This requires clarification.

145. More importantly, the principal observation that can be reached from Sanders and Phillipson's review is that the literature is very small, five studies only, with diverse methodologies. Though important and interesting, Sanders and Phillipson's work is arguably of academic value only, and should not be used as a reliable guide for public policy. Indeed, what they show is that no such guide currently exists. DECC should be given credit for having made some allowance for rebound effects, but it is difficult to place any great reliance on the figure employed.

146. This brings into focus a general point regarding the study of energy efficiency policies; the entire field is so primitive that very little can be definitely concluded, beyond the fact that the rebound effect is real. As Sorrell writes in the United Kingdom Energy Research Centre study, which is one of the most useful survey texts:

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50 John Stuart Mill, *Principles of Political Economy*, iv. 6. 9.

51 *Estimated Impacts* (2011), 28.

52 *Estimated Impacts* (2011), 53.

The available evidence for all types of rebound effects is limited and inconclusive. While the evidence is better for direct effects than for indirect effects, it remains focused on a small number of consumer energy services within the OECD countries. Both direct and indirect rebound effects appear to vary widely between different technologies, sectors and income groups and in most cases cannot be quantified with much confidence.[53]

147. In this state of knowledge we are thrown back on the history of energy efficiency and conservation measures, and in the following section we survey the record in the United Kingdom since 1945.

History of UK Energy Efficiency and Conservation Policies 1947–2012

148. Current governmental attempts to legislate for and encourage energy efficiency and conservation have important, and to some extent discouraging, precedents in recent history. The following section reviews experience in the United Kingdom since 1945.

149. Between the end of the Second World War and the present day there has been a wide range of attempts by government to improve energy efficiency, usually with the concurrent aim of conservation. Various forms of government legislation, restrictions on energy consuming activities, building regulations, price mechanisms, and public information campaigns have been employed.

150. In spite of this, the concepts of energy efficiency and conservation have never been clearly disentangled theoretically, or their relationship well understood, and consequently while technological advance has led to improvements in the efficiency with which we consume energy, total consumption has tended to increase.

151. Indeed, the history of this subject is dominated by a fundamental tension between governmental aspirations to conserve energy, for reasons of economy or security, on the one hand, and a social agenda, on the other, that requires improvements in standards of living that are dependent upon increased energy use. Efficiency has often been taken as a painless resolution of this difficulty, though in practice conservation has never materialized in an absolute sense, except, briefly, during the Second War, when the Ministry of Fuel and Power, itself created in 1942 as a spin-off from the Board of Trade and in recognition of the country's dependence on adequate energy supplies, attempted to conserve fuel for the war effort and to restrict domestic electricity consumption. This led to one of the earliest uses of a publicity campaign, in the press and on radio, to influence public perceptions (even Harrods opened an exhibition concerned with domestic fuel saving). Households were urged to "'Lag' to keep heat in" their boilers, and instructed to "Save Fuel for the Factories". Reduction in the consumption of electricity was a key objective, and one poster showed a cooking pan on an electric ring illustrated by the words "Turn it Low and behold – you're saving electricity". Another showed a ghost-like creature slipping through a gap around a window and emptying a sack of coal into its mouth. The slogan simply said "Draughts eat coal. Stop Draughts".

152. A review of the advertising used[54] shows that financial appeals are completely absent, the reader being expected to succumb to moral suasion and simply take the point as a reminder of a necessary contribution to the war effort, and though there was some use of price control, the government was able and keen to avoid full-scale rationing, which was politically controversial. In fact, did not increase for a year or so, and consumption was half a million tons below the government's coal budget, but the winter was mild, making it hard to say whether this was due to the campaign.[55] Consumption, however, rose steadily after 1943, and between that year and 1948 domestic electricity sales doubled.

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53 Steve Sorrell, *The Rebound Effect: An assessment of the evidence for economy-wide energy savings from improved energy efficiency* (UKERC: October, 2007), 87.

54 http://www.scienceandsociety.co.uk/

55 Angus Calder, *The People's War: Britain 1939–45* (Jonathan Cape: London, 1969), 285.

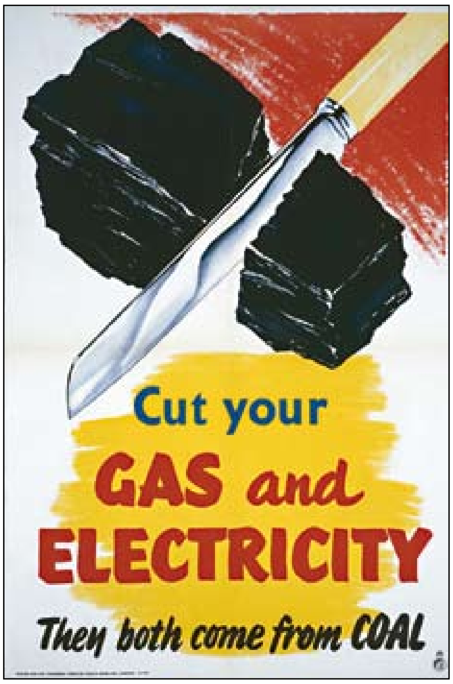

Figure 6: "Cut your Gas and Electricity". Poster issued by the Ministry of Fuel and Power (1942).
Source: Science & Society Picture Library.

153. Curiously, the use of electricity increased as a result of coal shortages that caused consumers to turn to electric space heaters (fuelled of course by coal-generated electricity) as a replacement for coal fires, and gas consumption also rose significantly in this period placing further pressure on coal, which was the principal source of gas at this time.

154. Subsequent attitudes to energy efficiency can be divided into four major phases, which we will review in turn:

- The post-war period and the energy crisis of 1947;
- A period of indifference from the later 1950s up until the early 1970s'
- The 'Oil Shocks' of the 1970s, and their consequences;
- The emergence of climate change as a global concern in the 1990s.

155. The first of these was brief, but acute. The unusually cold winter of 1946/7 coincided with shortages of plant, coal, and manpower, and coupled with government's underestimation of demand growth, led to blackouts and what was in effect electricity rationing. This had no small political significance, since it was the first major setback experienced by the hitherto popular Attlee government, and an early indication that state planning of the economy would prove very much more difficult than anticipated.

156. This crisis aside, the government's conservation measures were largely an effort to focus energy resources for the purposes of economic recovery in order to pay for a large and costly social program, and in this sense they were structurally similar to those employed during the war.

157. This situation eased through the mid 1950s, and with the notable exception of petrol rationing after the Suez crisis in 1956, the later part of that decade and the whole of the early 1960s saw steadily but not dramatically increasing energy consumption. Rapid global economic growth, largely driven by North American prosperity (itself grounded in cheap energy), drove up standards of living in the United Kingdom in spite of economic decline relative to other countries. Concerns with regard to energy did not disappear (the first building regulations relating to insulation appeared in 1965), but they were in abeyance.

158. A focused interest in conservation returned with the "oil shocks" of the 1970s, when security of supply and cost became the paramount considerations, not least because the turbulence in the international

oil markets coincided with the now marked decline in indigenous energy production, as can be seen in the following chart:

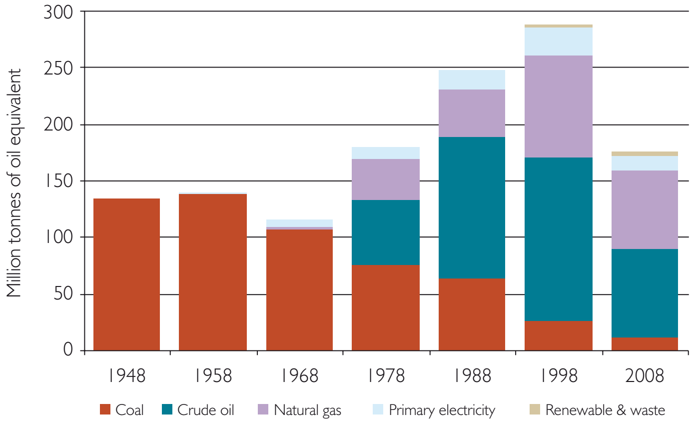

Figure 7: Indigenous production of energy in the United Kingdom. Source: Redrawn from data in DECC 2009.[56]

159. In response, governments mounted energy-saving campaigns with the explicit aim of conservation, and there was much spontaneous experimentation with renewable energy throughout the western world, Denmark laying the foundations for its wind industry at this time.

160. This phase ended for the UK with the emergence of new indigenous supplies of energy in the North Sea, and globally with the return of lower oil prices, the impact of which was to render uneconomic many of the conservation measures and suggestions for means of alternative supply, but the psychological effects of this period lingered long afterwards, and are arguably still an important presence in popular and political thought on this subject. This powerful role in public memory is hardly surprising. The first "Oil Shock" of 1973 pushed the price up by a factor of four.

161. Domestic coal production was also plagued by problems in labour relations. Government had responded to rising inflation in the early years of the decade by capping pay rises, resulting in a coal miner's strike, and a "work to rule" from the middle of 1973, when coal supplies were further restricted. In response, the Department of Energy announced a twelve-point interim programme of measures to save energy in 1974, including the "Save It" publicity campaign.

162. Material for "Save It" was jointly provided by the Department of Energy and the Central Office of Information. In contrast to the war time campaign, the emphasis was on the financial savings available, as can be seen in two of the campaign posters on the following page.

163. The first is directly in the tradition of the advertising of the Second World War, which we might call the "Dig for Victory" style, whereas the second employs a direct personal recommendation from a non-authoritarian figure, together with a large block of suasive text, a style of advertising common in the United States at the time.

164. Would-be humorous television advertisements on television showed actors dressed as birds regretting the presence of loft insulation since it made the roof tiles cold and gave them a "frozen parson's nose".[57]

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56 DECC, *60th Anniversary: Digest of United Kingdom Energy Statistics* (2009), 5. Available at: http://www. decc. gov. uk/assets/decc/statistics/publications/dukes/1_20090729135638_e_@@_dukes60. pdf

57 http://www. youtube. com/watch?v=Y8nOGKuU3Wk

Figure 8: Advertisements for the "Save It" campaign, 1970s. Source: Department of Energy.[58]

165. In addition to the publicity there was a tightening of building regulations, and thermal insulation requirements. Other measures to save energy included a temporary reduction in the motorway speed limit to 50 mph, from December 1973 to March 1974, and heating and lighting restrictions for non-domestic buildings (commonly known as the "Three Day Week"). Television companies were prohibited from broadcasting after 10.30 p.m., and a loan scheme for energy saving in industry was introduced.

166. The overall policy was formulated by the Central Policy Review Staff and the National Economic Development Office, and in 1974 both issued reports on conservation. An Advisory Council on Energy Conservation and the Energy Technology Support Unit at Harwell were appointed to advise the new Department of Energy.

167. Government promotion of conservation became a vital issue, backed by the "Save It" media campaign, as well as a series of booklets on energy savings in buildings issued by the Department of the Environment, and information on fuel saving in agriculture published by the Ministry of Agriculture, Fisheries and Food.

168. The "Save It" campaign initially got off to something of a false start since the National Coal Board and British Gas were still sponsoring campaigns to persuade consumers to use more of their particular product. Eventually, a coordinated effort including material sponsored by the energy utilities encouraging energy conservation was developed, including printed advertisements,

169. The House of Commons Select Committee on Science and Technology commissioned a study and in 1975 recommended an even more stringent set of measures to facilitate energy conservation, including compulsory targets for energy savings and statutory controls on thermal insulation standards for offices. The importance of conservation was hotly debated in Parliament during the passage of the Energy Bill in 1976, with both the Government and Opposition in agreement that energy conservation was vital in the pursuit of security of supply, particularly in the event of an "energy gap".[59]

58 Image supplied from the archive of the History of Advertising Trust (www. hatads. org. uk) to whom we offer our thanks for their assistance.

59 *Hansard* (October 1976).

170. 1977 saw the introduction of a package of measures designed to achieve energy savings. Curiously, they bear a strong resemblance to the current agenda, suggesting that after thirty-five years little has been achieved:

- Bring both private and public sector houses up to a basic level of insulation.
- Improve the efficiency with which energy is used in the public sector, both for its own sake and as an example to private consumers.
- Promote energy-saving investment in industry, commerce and agriculture.
- Demonstrate the value of new or adapted technology to industry, commerce and agriculture, and, through research, development and demonstration (RD&D), to put the UK in a position to take advantage of new technology as it becomes cost-effective.
- Reduce the rate of growth in demand for oil in transport.
- Develop a national awareness of the need for energy conservation.

171. Assessing the effectiveness of this effort is not straightforward, since the measurement of energy conservation is extremely difficult. However, it is estimated that during the period 1973-1982 energy consumption in the domestic sector increased by nearly 5%, partly explained by an increase in the number of households, and partly by a rise in ownership of appliances using electricity (colour televisions, freezers, and dishwashers). However, energy consumption for space and water heating per household showed a decline. The conclusion reached by two contemporary commentators seems reasonable:

> *Due to the increase in the number of households, energy use per household shows, if anything, a gradual fall, but energy conservation following the 1973 oil crisis seems as yet to have had little impact on total energy use in this sector.*[60]

172. It appears that the most effective means of energy conservation developed during this period was through building regulations in relation to new build houses, and building regulations were updated five times, in 1974, 1985, 1990, 1995, and 2002. During this period, building efficiency regulations, grant schemes, equipment labelling and standards may have reduced total energy use in housing by approximately 14%.

173. In 1979 with the new Conservative government, David Howell took over as Secretary of State for Energy, and the "Save It" campaign was abandoned, and it was not until 1983 that The Energy Efficiency Office (EEO) was established. Although this was intended to have control over energy conservation in other departments, it appears to have been initially underfunded.

174. In 1983 Peter Walker took over as Secretary of State for Energy and pursued a more interventionist approach, and between 1983 and 1987 more than 20,000 senior business executives held meetings with ministers to discuss energy efficiency.

175. This campaign set itself the goal of a 20% saving in each sector of the economy by 1995, with government programmes intended to stimulate just under £2 billion a year in savings. Industry and commerce were assisted with energy efficiency surveys and demonstration projects, monitoring and research and development programmes. Regional energy efficiency officers provided help to local SMEs, and an Energy Saving Show visited locations all over the country. Grants were given for water tank and loft insulation, and community insulation projects were initiated and home energy audits encouraged.

176. In addition, the "Energy World" demonstration project at Shenley Lodge, Milton Keynes constructed fifty-one low-energy houses designed to be at least 30% more efficient than demanded by the current regulations. This achieved international prominence, and the UK's first National Energy Rating Scheme

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60 Richard Bending and Richard Eden, *UK energy: structure, prospects, and policies* (Cambridge University Press: Cambridge, 1984).

evolved from the feedback from this scheme, which in turn became in 1995 the Standard Assessment Procedure or (SAP) rating scheme used in the National Building Regulations.

177. 1986 was declared "Energy Efficiency Year", and a major publicity campaign, designed by the Saatchi agency, was launched under the perhaps over-ingenious slogan of "Get more for your Monergy".

178. This campaign, which had a £70 million budget,[61] employed the by now familiar advertisements in print media as well as extensive public engagement. Asked in February to report on progress, Peter Walker described over 100 events, and "the first two Monergy breakfast briefings attended by 1,700 top executives".[62]

179. This emphasis on industrial and commercial efficiency is noteworthy, and non-domestic were targeted in the campaign:

Figure 9: "Get More for your Monergy" campaign poster, 1986. Source: History of Advertising Trust.

180. In addition, the campaign commissioned a series of public information films for television illustrating different means of saving money through the adoption of energy efficiency measures. The theme was loosely based on a version of the children's story, "Three Little Pigs", with two pigs (adults in pig suits) and one piglet shown saving money by installing a variety of devices in their home to protect themselves against the Big Bad Weatherman.[63]

181. The positive or negative impact of this element of the campaign is hard to establish empirically, but one may infer from their continued half-life on YouTube, alongside the Save It commercials, that they may have stimulated more ridicule than practical engagement, and may even have some part to play in explaining the low prestige of energy efficiency and saving in our own time.

182. Whether the campaign had any major impact is, again, difficult to determine. Final Energy Consumption was relatively stable over the period, even falling a little between 1978 and 1988, but this is probably explained by extreme economic difficulties, not by the cumulative effect of "Save It" and "Monergy", and in any case consumption quickly resumed its long-term trend of steady but undramatic increase.

61 Green, D. and S. Parsons, "Energy Efficiency Year 1986: What is in it for domestic consumers?", *Energy Policy* (1986), 98–100.

62 *Hansard* (17 Feb. 1986).

63 http://www. youtube. com/watch?v=_9PsK2dcMyA.

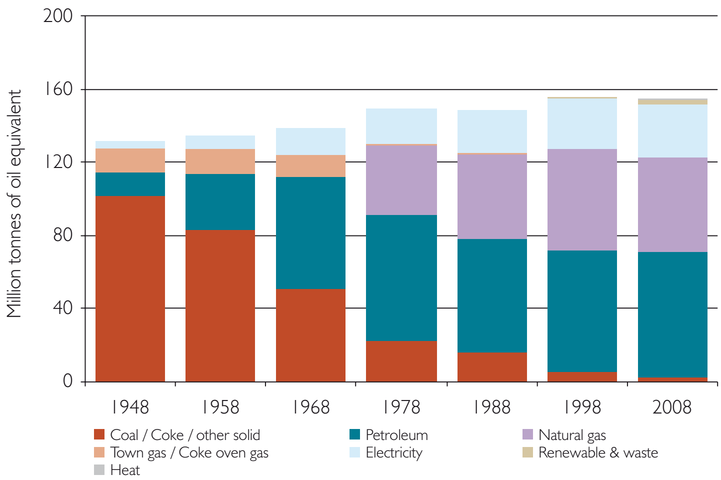

Figure 10: Final energy consumption in the United Kingdom. Source: Redrawn from data in DECC 2009.[64]

183. There have been no similar concerted campaigns subsequent to "Monergy", government preferring to work through oblique measures, such as the obligation placed on energy suppliers to provide efficiency measures to some customers through schemes such as the Energy Efficiency Standards of Performance (EESoP) scheme, discussed below, and quasi-independent agencies such as the Energy Savings Trust (created in 1993), whcih has continued to provide information to households and smaller businesses on energy efficiency and prevention of waste, and the Carbon Trust (founded in 2001), which has focused on larger businesses. However, both organizations, particularly the latter, have tended in recent years to describe their activities in terms of carbon emissions reductions without any clear recognition that this is not an isometric agenda.

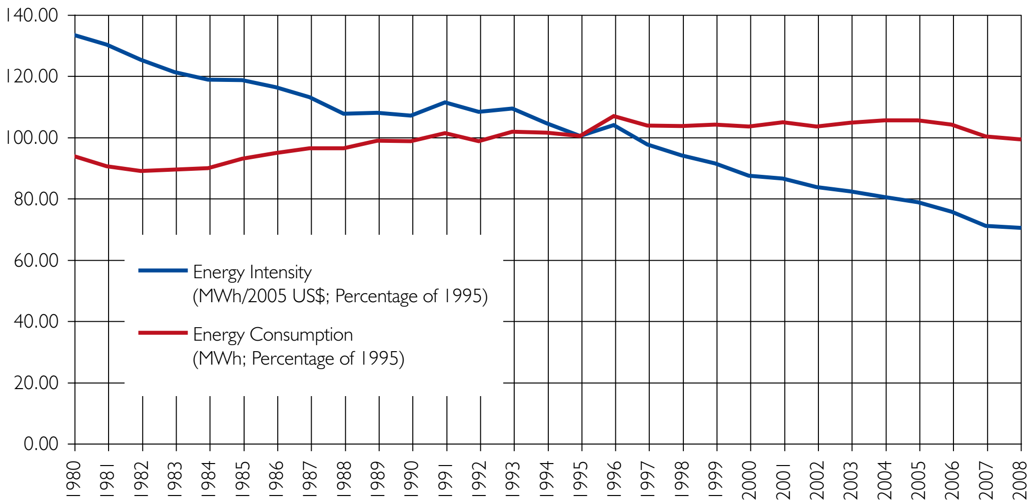

Figure 11: UK Energy Intensity (MWh/2005 US$; Percentage of 1995), blue line; and Energy Consumption (MWh; Percentage of 1995). Source: Chart by REF from World Bank Data.

184. Viewed charitably, it is conceivable that these programs have delivered some degree of relative energy conservation, but it is clear that conservation in the sense of an absolute reduction in energy consumption has not been achieved over the post-war period. Whether this is because of the failures of the campaigns or because of the inexorable logic of the Jevons Paradox is unclear, though the latter seems probable, as can be seen in Figure 11 above which tracks energy consumption per unit of wealth against total energy consumption over the economy.

64 DECC, *60th Anniversary: Digest of United Kingdom Energy Statistics* (2009), 8. Available at: http://www. decc. gov. uk/assets/ decc/statistics/publications/dukes/1_20090729135638_e_@@_dukes60. pdf

185. Viewed dispassionately, the historical record gives little reason for thinking that current attempts to deliver conservation through efficiency will fare better than those that have preceded them.

The Supplier Obligations

Estimated Costs of the Supplier Obligations

186. The breakdown of consumer bills in DECC's *Estimated Impacts* (2011) shows a number of items that fall into the broader category of domestic energy efficiency policies. These items add costs to the bills, but also offer potential savings. In this category we consider the following set of policies: Energy Efficiency Commitment 1 (EEC 1), Energy Efficiency Commitment (EEC 2), Carbon Emissions Reduction Target (CERT), the CERT extension, the Energy Company Obligation (ECO), the Green Deal, and the Community Energy Savings Plan (CESP). With the exception of the Green Deal, which is a financing scheme, these are all policies placing an obligation on energy suppliers to carry out energy efficiency improvements for selected customers, the cost of which is borne by all domestic energy consumers.

187. In terms of costs, DECC estimates that supporting this category of energy efficiency policies will add about 9% to the average electricity bill in 2020 and 5% to the average gas bill.

188. DECC's estimates of the value of the savings arising from these policies are 6% for gas bills and a more significant saving of 16% of electricity bills, implying an expected reduction in household energy usage of approximately 940 kWh per annum of gas and 681 kWh per annum of electricity in 2020.

189. What stands out in these figures is the disproportionately large electricity savings predicted to occur in 2020 due to the ECO and Green Deal; at £48 it is nearly ten times the savings anticipated in the gas bill. *Estimated Impacts* refers to expected switching from electric to gas heating under the ECO which may account for this disparity. However, this does not appear compatible with the Government's overall decarbonisation agenda. Furthermore, there is limited potential for offering gas heating to more households without extremely costly and probably uneconomic extensions to the gas network.

190. The following chart shows the savings expected from these policies and also the costs.

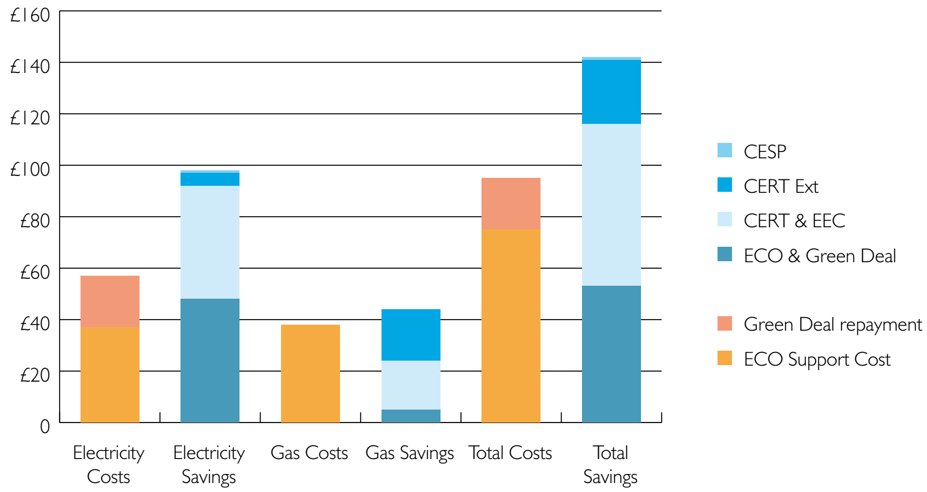

Figure 12: DECC's estimated costs and savings for average domestic bills in 2020 arising from the supplier obligations to provide energy efficiency measures. Source: DECC 2011.[65]

191. As will be immediately apparent, the Energy Company Obligation accounts for a very large share of the costs, while the previous energy schemes have no ongoing costs since they have already been paid for. Frustratingly, DECC has aggregated the benefits claimed for the ECO with those of the Green Deal, making a precise comparison of cost and benefit impossible.

65 DECC, *Estimated Impacts* (2011).

EESoP, EEC, CERT, CESP, ECO, Green Deal

192. Since 1992, the Government has imposed a series of initiatives and legal obligations on gas and electricity suppliers to carry out domestic energy efficiency projects, the costs of which are passed on to their customers as a whole. The earliest scheme involved the gas industry only but was followed by the Energy Efficiency Standards of Performance (EESoP) scheme for electricity suppliers, the first two phases of which ran from 1994 until 2000. The third phase included gas suppliers as well.

193. The EESoP scheme, developed and managed jointly by Ofgem and the Energy Savings Trust, allowed electricity suppliers to charge each domestic customer £1 per annum to finance the delivery of energy efficiency measures to UK households. Energy suppliers were set quantitative targets of energy to be saved by implementing energy efficiency measures such as insulation, low energy lighting, improved efficiency heating and appliances. The scheme had both social and environmental goals. Suppliers were required to focus two-thirds of expenditure on helping low income and disadvantaged households reduce their energy bills.

194. Since EESoP, there has been a succession of schemes, all sharing the fundamental principle of compelling energy suppliers to deliver domestic energy efficiency improvements to a selection of households, with funding being raised by a charge on all households.

195. The three phases of the EESoP scheme were followed by the two phase Energy Efficiency Commitment (EEC), which was in turn followed by the Carbon Emissions Reduction Target (CERT) and its extension. New legislation is in the pipeline to replace CERT with the Energy Company Obligation (ECO) and the Green Deal.

196. These new schemes entail a major expansion of the costs in comparison with earlier measures. Whereas the costs of the first phase of EESoP were capped at £1 per annum per customer, ECO will entail a charge of £75 per annum per customer in 2020, and those with a Green Deal measure as well will be paying £95 a year.

Table 8: *List of consumer-funded, domestic energy efficiency schemes delivered by energy suppliers.*

Scheme	*Duration*	*Target*
EESoP 1	1994–1998	6 TWh
EESoP 2	1998–2000	3 TWh
EESoP 3	2000–2002	11 TWh
EEC1	2002–2005	62 TWh
EEC2	2005–2008	130 TWh
CERT	2008–2011	154 million tonnes CO_2
CERT extension	2011–2012	293 million tonnes CO_2
ECO/Green Deal	2012–	

197. The targets set by EESoP were principally met through roof and wall insulation, but also included lighting, heating, and some appliances, such as more efficient refrigerators, and jug-shaped electric kettles which allowed consumers to see how much water was being boiled and to economise accordingly. The energy savings attributed to each measure were "deemed" (i.e. assumed without empirical measurements of individual real world results) based on average measured data from recognised sources such as the Building Research Establishment and the Energy Saving Trust.

198. EESoP was rolled over into the Energy Efficiency Commitment (EEC) in 2002. Whereas EESoP was designed to mitigate fuel poverty, EEC included the aspiration to mitigate climate change by reducing carbon emissions. Thus, EEC was required to reduce domestic carbon dioxide emissions by 1% per annum as well as deliver at least 50% of the EEC efficiency target to a Priority Group of consumers, defined as those in receipt of certain income-related benefits and tax credits.

199. Other differences introduced with EEC were that suppliers were not required to spend a fixed amount of money, nor were they restricted to their own customer base. Furthermore, they had flexibility over the types of measures that they could use to meet their targets.

200. As with EESoP, deeming was used to quantify the savings of specified sets of energy efficiency measures. Consequently, some measures were easier and cheaper for suppliers; for example, nearly 40 million low-energy light bulbs were distributed in the three years to 2005, and some suppliers largely relied on this single measure to meet their EEC obligations.

201. Sales of three million refrigerators and freezers, or one quarter of the total sales of cold appliances, and 3.5 million dishwashers and/or washing machines were subsidised under the EEC obligation. However, less than 20% of these appliances went to Priority Group consumers. This bizarre outcome was the result of switching the emphasis of policies from the mitigation of fuel poverty, which implied social targeting, to the mitigation of climate change, which did not.

202. In 2008, EEC was replaced by the Carbon Emissions Reduction Target (CERT), in which the targets for insulation and other energy efficiency measures were recast in terms of savings in the amount of carbon dioxide emitted by householders. The primary aim of CERT was to make a contribution to the UK's legally binding target under the Kyoto Protocol (to cut greenhouse gas emissions by 12.5% below 1990 levels by 2008-2012) and the requirements of the Climate Change Act 2008 (to cut emissions of greenhouse gas emissions by 80% below 1990 levels by 2050).

203. At least 40% of the CERT target reduction of 293 million tonnes of carbon dioxide was ring-fenced for a Priority Group of certain low-income domestic consumers, or those over 70 years old, and legislation specifically required that 73.4 million lifetime tonnes of carbon dioxide must be delivered through insulation measures. (For an explanation of "lifetime tonnes", see paragraph 204 below.)

204. With CERT, carbon dioxide emissions savings are also deemed, and Ofgem is responsible for awarding suppliers points towards the targets for each measure they install. The measures are allocated a lifetime and a carbon score based on modeled savings. For example, the loft insulation of a one bedroom flat scores between 95 and 388kg carbon dioxide per annum (depending on the thickness of insulation added) and has an expected lifetime of forty years. The cavity wall insulation of a one bedroom flat scores 242kg carbon dioxide per annum over a lifetime of forty years, whereas switching a one bedroom flat from full electric central heating to gas central heating scores 1,479kg carbon dioxide per annum. Appliances are also included, with a standard A+ rated fridge/freezer scoring 26kg carbon dioxide per annum with a lifetime of fifteen years.[66]

205. Some measures have a more tenuous link to credible carbon dioxide emissions or energy savings. For example, providing a Home Energy Advice Package which consists of a survey, advice and a report is deemed to be equivalent to savings of 0.675 lifetime tonnes of carbon dioxide. Supplying a Real Time Display to provide information about the customer's electricity consumption is equivalent to abating 0.996 lifetime tonnes of carbon dioxide.

66 http://www.ofgem.gov.uk/Pages/MoreInformation.aspx?docid=60&refer=Sustainability/Environment/EnergyEff/InfProjMngrs

Table 9: *Key measures installed under CERT as at end December 2011*[67]

	Measure Type	*Number of Measures*
Insulation	Loft Insulation (excluding DIY)	2,613,690
	Cavity Wall Insulation	1,933,868
	Solid Wall Insulation	45,145
Heating	Fuel Switching	81,798
Lighting	Compact Fluorescent Lamps	303,522,721
Microgeneration	Heat pumps	6,576
	Solar water heating (m^2)	3,091
Behavioural	Real Time Displays	2,401,212
	Home Energy Advice Packages	28,571

206. This scoring system again incentivises least-cost delivery of measures but also allowed some exploitation of the scheme and its objectives. Most notably in the case of over-delivery of free Compact Fluorescent Lamps (CFLs), some of which were not actually wanted nor installed. Consequently, CFLs were excluded from the CERT extension phase of the policy which runs from 2011 to 2012.

207. The Community Energy Savings Programme (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. It is restricted to specific low-income urban areas.

208. CERT and CESP are due to be replaced in 2013 by a new Energy Company Obligation (ECO) and the Green Deal.

209. The Green Deal is a mechanism allowing individuals and businesses access to the finance needed to make energy efficiency improvements to their buildings at no upfront cost. Repayments, in installments, will be attached to the energy bills of the relevant building, and the Green Deal is targeted at measures where the costs can be readily covered by expected energy savings.

210. The Energy Company Obligation (ECO) is a backstop to the Green Deal and will have two objectives. One is to provide a mechanism for delivering cost-effective measures that would be deemed too expensive for Green Deal measures. Solid wall insulation is an example as its costs would violate the Golden Rule requiring energy savings in monetary terms to be greater than expenditure on the measure implemented. The second objective of the ECO is to provide affordable warmth for lower income and vulnerable households

Real World Performance of Efficiency and Conservation Measures

211. It is generally accepted that household energy efficiency policies – particularly the insulation measures – have saved and will continue to save energy for the households who have received these measures. However, precise quantification of these savings is almost impossible, the primary problem being that there is no comprehensive evaluation system designed into the individual policies to assess all of the outcomes and impacts and, where appropriate, attribute these to the policies.[68]

212. Consequently, there are a number of difficulties in assessing the validity of the predicted costs and savings attributed by DECC to these measures in current policies, principal amongst which is the fact that the energy savings benefits are "deemed" values based on modeled outcomes. Unfortunately, the models are almost certainly misleading in relation to real world performance, and in the relatively few cases where empirical data has been compared with modeled predictions the measures have been found to underperform.

67 http://www.ofgem.gov.uk/Sustainability/Environment/EnergyEff/CU/Documents1/OfGem%20CERT%20Q15%20March%202012_WEB.pdf

68 http://www.decc.gov.uk/assets/decc/11/funding-support/3340-evaluation-synthesis-of-energy-supplier-obligation.pdf

213. One such study was led by Professor Tadj Oreszczyn at University College London and compared energy consumption for space heating before and after installation of energy efficiency measures. While a theoretical improvement of 25–35% in energy consumption was predicted, the actual measured improvements were negligible, with the performance of insulation measures and switching from individual room heaters to new efficient central heating systems falling short of their theoretical predictions. Measurements of air-tightness of the dwellings before and after the interventions in some cases also failed to show the expected improvements.

214. The measured data revealed that models provided a poor indication of actual space heating energy consumption. The conclusions drawn are that the supposed energy improvements did not deliver the expected reduction in fuel consumption.

215. The normal explanation for these differences is the so-called "comfort taking" or rebound, whereby householders prefer to enjoy warmer conditions in their homes than take the savings, so maintaining expenditure on energy at roughly the same level. However, these effects were recognised and had already been taken into account.

216. Some of the difference between the expected and actual energy savings was attributed to reduced airtightness 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.

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

218. It was also concluded that the models may over-estimate energy savings by making the assumption that the new measures are used in the most energy efficient way by the householder. In practice, many people 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.

219. Houses of the same theoretical efficiency will not necessarily use the same amount of energy. 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 compares twelve new but nearly identical properties from a single housing development. All of the properties had a pre-build projected 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, reflecting the variation of energy requirements across household types; while some individuals may be at home all day, and may need extra heat for health reasons, others may work away from home or simply not need to heat their homes for as long.

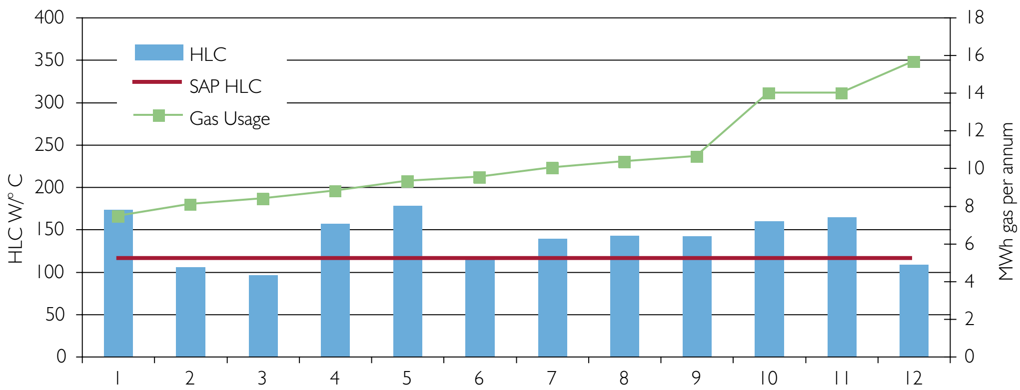

Figure 13: Comparison of predicted SAP and measured heat loss coefficients (HLC) for 12 nearly identical new-build properties and the annual gas use. Source: Carbon Trust.[69]

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

220. A study which explored the effectiveness of energy performance regulations in lowering the energy consumption of dwellings built in the Netherlands after 1996 also noted that there was a lack of correlation between expected and actual energy consumption which was attributed in part to the effect of occupant behaviour on energy consumption. A householder's lifestyle can have a significant impact on how much energy is actually saved by a particular efficiency measure.

221. Empirical data such as this suggests that DECC's current assumptions that the benefits of the Supplier Obligations for domestic household efficiency measures will offset the costs of other policies may be in error.

222. We note that it is unclear what assumption DECC may have made in regard to underperformance, aside from that implicit in the Standard Assessment Procedure (SAP).[70]

223. In relation to CERT, the department writes in Annex B of *Estimated Impacts*:

> *The estimated efficiency savings from CERT allow for a comfort factor of 15% for insulation measures. They also reflect some degree of underperformance and under use of measures distributed based on available evidence.*

224. In relation to ECO and Green Deal they remark that "*The efficiency savings from the household measures include an 'underperformance" factor based on a review of measured versus theoretical energy savings*", and refer to Sanders and Phillipson's work for Ofgem,[71] which reports an overall reduction factor of 50% for insulation measures, of which 15 percentage points are accounted for by comfort taking (the rebound effect). However, it is unclear from DECC's remarks whether the 35% underperformance assumption recommended by Sanders and Phillipson on the basis of a literature review has been used in both cases, or indeed in either. This requires clarification.

225. Further doubts relating to the supplier obligations relate to the cost assumptions made by DECC. There is no legal requirement for energy companies to provide any information about the costs of delivering, or the levels of cross-subsidies for CERT or CESP, and apparently they have been reluctant to divulge such commercially sensitive information in retrospective research.[72] A DECC evaluation has noted that this has limited the ability for assessing exactly how cost-effective CERT and CESP are, and how costs are passed on through the supply chain or to consumers.

226. The consumer organization *Which* has noted the absence of financial monitoring for CERT, and the fact that this makes it impossible to determine whether it provides value for money.[73] Suppliers are currently allowed to pass the estimated cost they incur for CERT straight through to customers. However, there is no way of knowing if suppliers pass this on to customers in full, in part, or with a premium in excess of the actual cost. Because of the lack of transparency around costs, *Which* also considers that there are no checks to ensure that maximum carbon savings are delivered for the money spent.

227. This lack of transparency for current supplier obligations suggests that DECC's costing of Supplier Obligations in 2020 is not likely to be empirically grounded, a fact that does not inspire confidence. We suspect that the ultimate cost to consumers could be significantly higher than those described in DECC's *Estimated Impacts* (2011).

Capital Cost and Risk of Backfire

228. We have drawn attention above to the immature state of the academic literature on energy efficiency and its outcomes, noting that it is only recently that Jevons' insights have been subjected to rigorous

70 *Estimated Impacts* (2011), 28.

71 Sanders, Chris, and Mark Phillipson, *Review of Differences between Measured and Theoretical Energy Savings for Insulation Measures* (Centre for Research on Indoor Climate and Health: Glasgow Caledonian University: December 2006).

72 Evaluation synthesis of energy supplier obligation policies, DECC, October, 2011. http://www.decc.gov.uk/assets/decc/11/funding-support/3340-evaluation-synthesis-of-energy-supplier-obligation.pdf

73 http://www.which.co.uk/documents/pdf/cert-supplier-guidance-consultation-which-response-237754.pdf

examination, refinement, and extension, and that the field has not yet reached conclusions that are sufficiently robust to form a foundation for public policy. However, the reality of the rebound effect is well established, with research now attempting to generate empirical data to support refined understanding of the extent of rebound effects, and the sectors that are prone or more or less immune to their effects.

229. An important example of this work is Mizobuchi's 2008 paper on the effect of capital cost on rebound effects in the domestic sector.[74] Using Japanese household data Mizobuchi builds on earlier work suggesting that when the capital cost of an energy efficiency measure is taken into account then the rebound effect will be much smaller. To put it simply, the capital cost of an energy efficiency measure has a variety of economic effects on household behaviour and tends to decrease the likelihood of behaviour that would create a rebound in energy consumption.

230. In a key paper that usefully summarises much of the more sophisticated thinking on rebound effects, Sorrell and Dimitropoulos wrote:

> *[…] higher capital costs will only reduce the rebound effect if the consumer faces the full cost of the purchase decision. If, for example, the additional cost of energy efficient conversion devices is fully subsidized, the higher initial cost should not affect the purchase decision. Furthermore, if government subsidies make energy efficient devices cheaper than inefficient models, it is possible that the rebound effect will be amplified[.]*[75]

231. Mizobuchi's findings confirm this, suggesting from his own data set, which refers for the most part to more efficient domestic appliances, that the influence of capital cost holds rebound effects down to around 27%, whereas if they are not taken into account theory would predict a rebound of 115%, i.e. a backfire, when more energy is used after the efficiency measure has been applied than was used before.

232. In passing we note that a 27% rebound effect for efficient domestic appliances is in itself very significant, and gives cause for concern with regard to DECC's extreme reliance on the Products Policy.

233. While DECC could take comfort from the fact that many estimates of rebound effects have hitherto tended to neglect capital cost effects, and Mizobuchi's work suggests that this may be a significant source of error, this finding will only apply` where capital costs bear down on the household and exert a braking effect reducing the extent of rebound. If, as Sorrell and Dimitropoulos remark, subsidies reduce or even remove the influence of capital cost, then the rebound effect will be that much larger.

234. Many of the UK government policies expected to deliver significant energy savings, particularly to those on lower incomes, shield the householder against the capital cost of the energy efficiency measure: for example, the Green Deal, the Energy Company Obligation (ECO), the Carbon Emissions Reduction Target (CERT), and the Energy Efficiency Commitment (EEC).

235. Thus, on the view presented by Mizobuchi, these well-intentioned policies may actually increase the likelihood of high rebound and even backfire.

236. Our point here is not to suggest that the Green Deal or ECO will certainly result in major rebound or backfire effects, but rather that the nature of contemporary understanding is sufficient to show that it may well do so, and that in the light of this risk, public policy should not place firm reliance on energy efficiency measures to deliver savings of any particular magnitude.

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74 Mizobuchi, K., 2008. An empirical study on the rebound effect considering capital costs. *Energy Economics 30:* 2486–2516.

75 Sorrell, and J. Dimitropoulos, 2008, "The rebound effect: Microeconomic definitions, limitations and extensions", *Ecological Economics*, 65, 636–649.

Smart Metering

237. Government hopes for the installation and effectiveness of smart meters are best described in DECC's own words:

> *The Government's vision is for every home in Great Britain to have smart energy meters, with business and public sector users also having smart or advanced energy metering suited to their needs.*
>
> *[…]*
>
> *Consumers will have real time information on their energy consumption to help them control and manage their energy use, save money and reduce emissions. Smart meters will also provide consumers with more accurate information and bring an end to estimated billing.*
>
> *Energy suppliers will be responsible for replacing over 53 million gas and electricity meters, involving visits to 30 million homes and small businesses. The mass roll-out of smart meters is expected to start in 2014 and to be completed in 2019. The majority of consumers will receive their smart meters during the mass roll-out.*

238. That is to say, smart meters are expected to assist consumers in reducing their consumption, or cut costs by shifting consumption to cheaper periods, to cut the costs of electricity suppliers by removing the need for meter readers, to reduce energy theft, and to reduce the time taken to respond to outages. In addition, and this is perhaps the principal reason for their adoption, there are hopes that smart meters may facilitate the use of domestic demand as part of a controllable load option intend to assist in balancing the electricity network in the presence of large volumes of uncontrollable renewables.

239. The total cost of the scheme is estimated in the government's own Impact Assessment to be just under £10.76 billion for the domestic sector and £574 million for the small and medium non-domestic sector.[76] DECC's breakdown of the domestic cost figures is as follows:

> *Capital costs, installation, and opex costs amount to £6.29bn. Comms costs amount to £2.11bn. IT costs amount to £1.03bn. Legal, marketing, setup, disposal, energy, pavement reading inefficiency and integration of early meter into DCC [Data and Communications Company] costs amount to £1.33bn.*

240. The figure assigned to the IT costs of what is, after all, a very large and probably difficult information processing project, seems implausibly low, and recent experience of government procurement of other nationwide data projects of a similar scale is not encouraging.

241. However, accepting these figures for the sake of argument, DECC expects the costs of the smart meter program to be outweighed by the benefits, of some £15.8 billion, though it should be remembered that these are spread out over two decades, unlike the costs which are concentrated in the next seven years:

> *Total consumer benefits amount to £4.64bn and include savings from reduced energy consumption (£4.60bn), and microgeneration (£36m). Total supplier benefits amount to £8.57bn and include avoided site visits (£3.18bn), and reduced inquiries and customer overheads (£1.24bn). Total network benefits amount to £780m and generation benefits to £774m. UK-wide benefits from carbon savings amount to £1.1bn.*

242. In addition, and crucially for DECC's expectations with regard to the cost-offsetting impact of the Smart Meter program, there must be considerable doubt as to whether all domestic households can in fact be fitted with the devices in the required time.

Will the Products Policy Deliver?

243. An important conclusion of our discussion above is that performance of the Products Policy is crucial to DECC's expectations. Indeed, for the 65% of households who see a net increase in bills, this single

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76 http://www.decc.gov.uk/assets/decc/Consultations/smart-meter-imp-prospectus/1485-impact-assessment-smart-metering-implementation-p.pdf

policy accounts for over two thirds of the savings that helps to contain that increase in their bills. Specifically, the Products Policy accounts for £158 of £215 of anticipated savings for those households, suggesting extreme over-dependence on one policy.

244. This matter is not as clear as it should be from *Estimated Impacts*, and in point of fact the infographic is misleadingly drawn, since the costs and savings bars are not proportional to the figures represented. In the following image we have redrawn the costs and savings bars to rectify this matter.

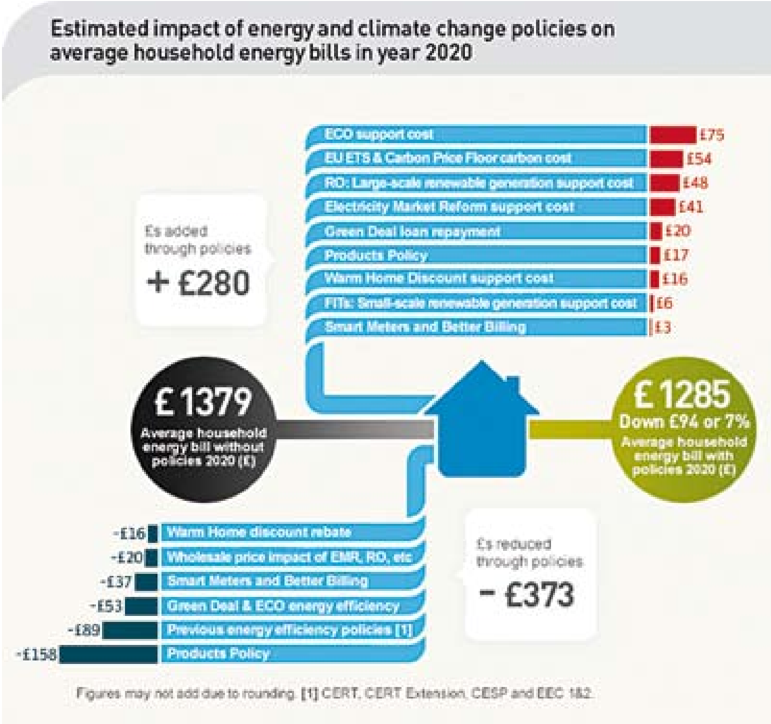

Figure 14: DECC's infographic of estimated impact of energy and climate change policies on average household energy bills in 2020, redrawn by REF to with the costs (red) and savings (dark blue) bars correctly scaled. Source: DECC, corrected by REF.

245. In this corrected form the graphic shows immediately that DECC's overall approach to the mitigation of household impacts is heavily reliant on one policy set, the Products Policy. A stacked bar chart illustrates this point still more clearly:

Figure 15: Savings due to policies (£). Source: DECC, Chart drawn by REF.

246. The details of the Products Policy have not been subject to the public fanfare accompanying other measures such as the Green Deal, and are therefore little discussed outside specialist circles. However, the strength and character of assumptions regarding this policy are crucial to DECC's claim that its policies are benign and prudent, since it is for the 65% of households that will not benefit from the Green Deal, ECO, the CERTs, CESP, or EEC, the principal defence against rising prices.

247. Indeed, it is no exaggeration to say that if the Products Policy underperforms significantly the price effects of policies will weigh heavily on consumers irrespective of the performance of other cost-reducing policies.

248. In the following section we examine the Products Policy and discuss the plausibility of DECC's expectations for these measures.

EU Legislation

249. The "Products Policy" is the label given to legislation promoting energy saving by setting legally binding minimum energy efficiency standards for electrical equipment such as refrigerators, dishwashers, washing machines, televisions, lights, and a variety of other devices.

250. The EU Ecodesign Directive, adopted in 2005, established the principle for the EU-wide setting of consistent minimum standards requiring an increasing reduction in energy consumption and other environmental impacts for energy-using products. In 2009 this Directive was extended to include so-called Energy Related Products, such as windows, insulation material, shower heads and taps, which do not use energy themselves but have an impact on energy consumption and can, therefore, contribute to saving energy.

251. The aim of the policy is to remove from the market the least energy efficient products, and to set incrementally more stringent minimum requirements for energy usage.

252. The Directive is a so-called *Framework Directive*, in other words it establishes the general principles, with the actual legal obligations on manufacturers expected to follow afterwards in a range of *Implementing Measures* for different product groups.

253. The Implementing Measures spell out the environmental standards for specific electrical equipment. They place an obligation on manufacturers to assess the environmental impacts of their product, to comply with eco-design requirements, to use EU-harmonised standards and labels, and carry out compliance testing. Meeting these obligations entitles the product to carry the CE logo which is a passport permitting the product to be freely traded within the European market.

254. The Ecodesign Directive also permits industry to enter into voluntary agreements as a valid alternative to mandatory requirements. The voluntary agreement must be agreed by a majority of the product sector involved and achieve the same objectives as binding legislation in a more rapid and cost-effective manner. It must include credible monitoring and reporting (including independent inspections).

255. In practice, voluntary agreements are limited; the European Commission is "likely" to endorse an industry agreement for complex set top boxes.[77] Only three other product groups[78] have had voluntary agreements proposed to date.

256. Products subject to the Directive have been chosen on the basis that they have the highest potential for reduction of greenhouse gas emissions, either because they have a significant volume of sales and trades in the EU, or have a significant environmental impact during their life cycle or there is significant potential for improvement.

257. There is a substantial delay in the Implementing Measures being adopted because the process itself is not very efficient, requiring a number of stages for drafts, working plans, impact assessments, and

77 http://www. eceee. org/Eco_design/process/Voluntary_Agreements
78 Imaging equipment, machine tools, and medical imaging equipment.

stakeholder consultations to be carried out. It has taken six years for the first twelve Implementing Measures, listed in Table 10 below, to be adopted.

258. At worst, this process has taken nearly five years for complete development of efficiency regulations for a product group, but regulation for water heaters and boilers is still pending after almost six years.[79] A further delay is built into the process to allow manufacturers time to bring their products into compliance after the legislation is adopted. Consequently, there is a potential time lag of many years before that legislation can have a visible impact.

259. The first tranche of product groups listed in Table 10 is part of a larger set of 40 products comprising the first working phase of the Directive. Legislation for the remaining products is not yet in place. Meanwhile, work at the EU level has commenced on identifying the next set of product groups to be considered. It is clear that the task is herculean and progress slow.

260. However, the potential for energy savings is estimated to be large. For example, the efficiency measures mapped out for the twelve product groups in Table 10 are predicted to save EU countries approximately 376 TWh per year in 2020, which represents about 14% of the EU's 2009 Final Electricity Consumption (i.e. energy consumed in final conversion devices, such as electric lights or a gas boiler).

261. There is related legislation that also has an impact on take-up of energy efficient appliances, the most significant being the Energy Labeling Directive, 92/75/EEC. This established an energy labelling scheme designed to inform and encourage consumers to choose the most energy efficient equipment. Appliances must display an EU Energy Label showing its energy efficiency on a colour-coded scale ranging from A+++ to G, as well as summarizing other technical performance efficiencies such as water consumption and noise emissions.

Table 10: *EU Adopted Implementing Measures for Electrical Appliances, the dates of adoption and the timetabled dates for achieving first and second phases of energy efficiency measures. Source EU.*[80]

	Date of Adoption of Specific Efficiency Legislation	*First Tier Improvements*	*Second Tier Improvements*
Standby and off mode electric power consumption	December 2008	December 2009	December 2012
Simple set top boxes	February 2009	February 2010	February 2012
Domestic lighting	March 2009	September 2009	September 2010
Tertiary lighting	March 2009	April 2010	April 2012
External power supplies	April 2009	April 2010	April 2011
Domestic refrigerators & freezers	July 2009	July 2010	July 2013
Electric motors 1-150 kW	July 2009	June 2011	January 2015
Televisions	July 2009	August 2010	April 2012
Circulators in buildings	September 2009	January 2013	August 2015
Domestic dishwashers	December 2010	December 2011	December 2013
Domestic washing machines	December 2010	December 2011	December 2013
Ventilation Fans	April 2011	January 2013	January 2015

79 See CSES Evaluation of the Ecodesign Directive (2009/125/EC) March 2012 http://www. cses. co. uk/ecodesign_evaluation/documents/

80 http://ec. europa. eu/enterprise/policies/sustainable-business/ecodesign/product-groups/index_en. htm

Potential in the UK

262. The potential to achieve energy savings in the UK domestic sector by improving the efficiency of electrical appliances is also assumed to be substantial. The average electricity consumption per UK household is approximately 4,500 kWh per annum.[81] However, this figure is distorted towards higher values by the fraction of UK houses in which electricity is used for heating. For those households, the electricity usage would need to be two to three times the average quantity to match the comfort levels of an average gas heated house.

263. An arguably more realistic figure for electricity used for lighting and electrical appliances, and thus, demonstrating the potential for products policy impacts, is the median electricity consumption usage, which is 3,300 kWh per annum.[82] Given that there are 26 million households in the UK this amounts to a total of 86 TWh compared with the UK's final electricity consumption of 320 TWh.[83] Thus, we can conclude that **approximately 27% of the UK final electricity consumption is used for domestic lighting and electrical appliances**.

264. The question, then, is how much of the 3,300 kWh per annum can the average household realistically save in 2020 by upgrading electrical appliances to those with improved electrical efficiency?

265. DECC's assumptions on this point can be calculated from *Estimated Impacts* (2011), table F2 of which shows that in 2020 the products policy is predicted to result in an annual saving of £158 on the average household electricity bill. Annex C of the document gives a summary of the assumptions inherent in DECC's modeling, and from these we learn that "*energy efficiency savings are valued at final (after all policies) energy prices and the cost impact of policies is estimated using baseline (before all policies) energy consumption*".

266. From this we conclude that DECC has valued the estimated savings attributed to the climate change policies at 18p per kWh, but valued the increased costs of the climate change policies at 14p per kWh.

267. The £158 saving attributed to the Products Policy equates to a reduction in electricity usage of 885 kWh per average household per year, i. e. approximately 27% of current median electricity consumption.

268. In 2020, when the number of UK households is predicted to have increased to 28 million,[84] this saving would amount to 25 TWh per annum.

269. Comfort that this logic produces a result which tallies with Government assumptions can be taken from the answer given by Richard Benyon, Parliamentary Under-Secretary of State of the Department of Environment, Food and Rural Affairs to a parliamentary question asked by Douglas Carswell MP, on the 26th of March, 2012:

> ***Douglas Carswell:*** *To ask the Secretary of State for Environment, Food and Rural Affairs what estimate her Department has made of projected annual electricity savings in the domestic sector in gigawatt hours in (a) 2020 and (b) 2030 arising from the introduction of minimum EU energy and environmental performance standards.*
>
> ***Richard Benyon:*** *A number of minimum EU energy performance and labeling standards, many of which apply in the domestic sector, are being developed in two tranches. The first tranche has already been agreed across member states, and the second tranche is in the process of being agreed.*

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81 This can be derived from the final electricity consumption figures attributed to domestic use divided by the number of households see ET5. 2.

82 For median domestic electricity consumption see http://www. decc. gov. uk/assets/decc/11/stats/publications/energy-trends/4779-energy-trends-mar12. pdf

83 DECC's Energy Trends data "Supply and Consumption of Electricity (ET5. 2). http://www. decc. gov. uk/en/content/cms/statistics/energy_stats/source/electricity/electricity. aspx

84 http://www. eci. ox. ac. uk/research/energy/downloads/lcfreport/appendix-s. pdf

Domestic electricity savings for tranche 1 policies are projected to be just under 17,000 GWh in 2020 and just over 12,000 GWh in 2030. Domestic electricity savings for tranche 2 policies are estimated to be just over 8,000 GWh in 2020 and just under 9,000 GWh in 2030, although it should be noted that the scope, timing and stringency of tranche 2 minimum standards are still in the process of being agreed across member states, and so the estimate cannot be made with certainty.

These estimates do not include associated increases in gas emissions (where the heat previously produced by less efficient products will need to be generated from another source), and neither are standards that aim to reduce gas consumption included. Estimated impacts beyond 2020 are of course subject to considerable uncertainty, because of difficulties predicting how the market will respond to delivering more efficient products in the longer term.[85]

270. Thus the 25 TWh per annum savings that we have derived from Table F2 of *Estimated Impacts* corresponds with the sum of the savings predicted in 2020 from what are described as Tranche 1 and Tranche 2 policies in the answer to the parliamentary question. However, the answer makes it clear that one third of DECC's Product Policy savings is described by DEFRA as "uncertain". It does not seem reasonable to include such uncertain measures in cost-offsetting calculations, but this is exactly what DECC has done.

Products Policy Savings: Type and Location

271. The scale of the energy efficiency challenge for the Products Policy can be seen in the following figure, which shows the comparative share of household electricity consumed by various electric appliances.

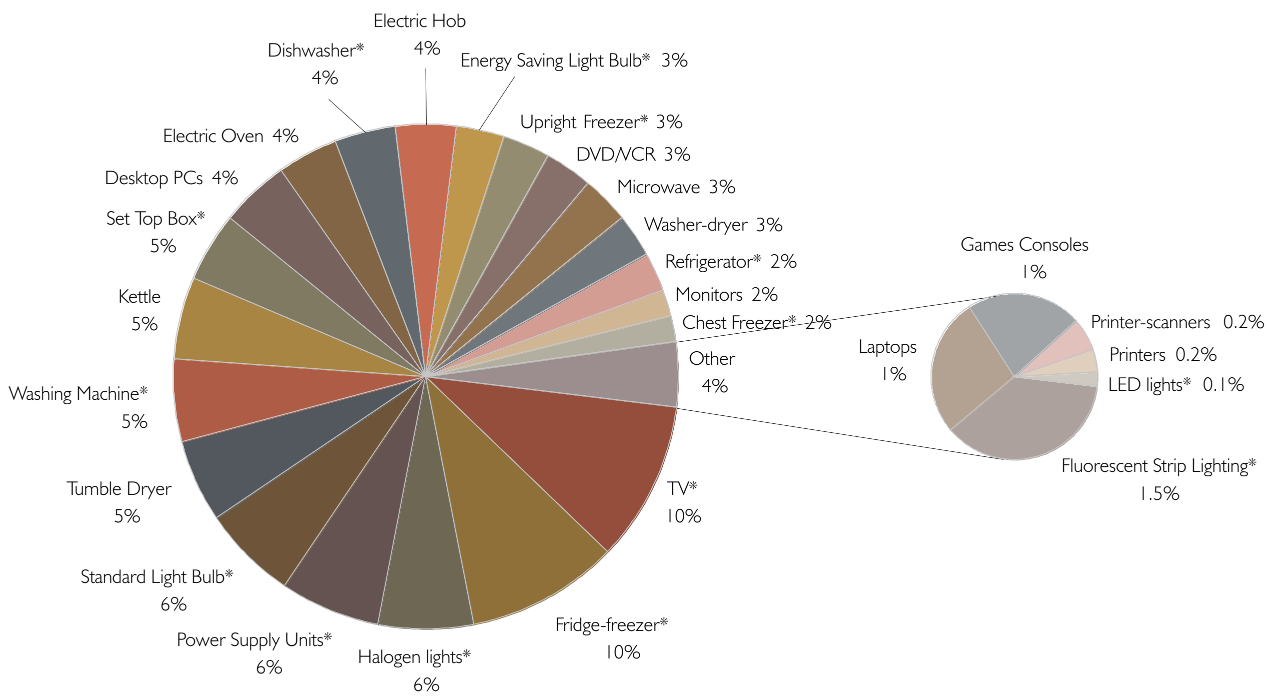

Figure 16. Electricity consumption by household domestic appliances. The asterisked items are included in the first tranche of EU efficiency measures. Source data: Market Transformation Programme for DEFRA, Energy consumption in the UK, Domestic Data Tables, 15 September, 2011.[86]

272. The chart shows that achieving DECC's planned reduction of 27% of domestic electricity consumption requires simultaneous efficiency improvements in a very wide range of products in the next eight years. This will not be easy to deliver.

85 See Hansard 20 March 2012. http://www.publications.parliament.uk/pa/cm201212/cmhansrd/cm120326/text/120326w0001.htm#12032628000388

86 http://www. decc. gov. uk/en/content/cms/statistics/publications/ecuk/ecuk. aspx

273. DEFRA has attempted to predict where the projected UK efficiency savings will be achieved for the first eleven product groups, and the European Commission has done the same for the EU as a whole. However, studying these two estimates together raises doubts about the modeling. DEFRA anticipates improvements in standby power consumption in electrical equipment such that 90% of UK standby savings are made in the domestic sector, and that 16% of the EU-wide standby savings are made in the UK domestic sector, which does not seem probable.

274. The results for refrigerators and freezers are similarly implausible, since the UK domestic sector is anticipated to be responsible for 30% of EU-wide savings for refrigerators and freezers.

275. We conclude from these rather startling results that modeling energy efficiency savings is an inexact science, and that without empirical data many of the predicted energy savings are guesswork at best.

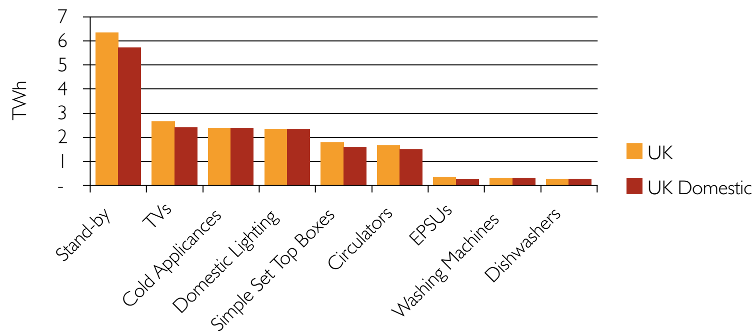

Figure 17. Modeled energy savings for 2020 as a result of the products policy attributed to efficiency improvements in equipment used in the UK domestic sector and the UK as a whole. Source data: DEFRA.

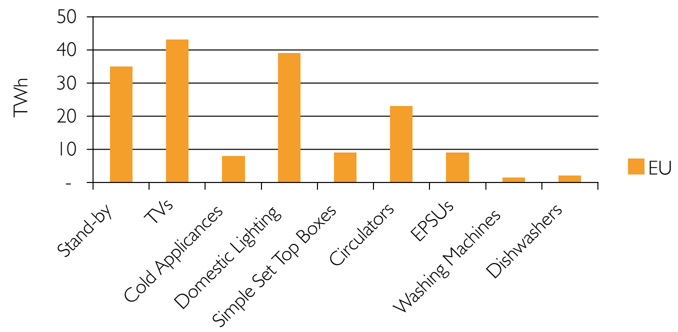

Figure 18. Modeled energy savings for 2020 as a result of the Ecodesign directive attributed to efficiency improvements in equipment used in the EU as a whole. Source data: EU.[87]

276. Careful monitoring of device compliance is essential if we are to have confidence in the costs savings assumed for efficiency improvements. The Eco-design policy requires each country to carry out market surveillance in order to ensure that products comply with the standards set out in the relevant Implementing Measures. However, compliance with the mandatory energy efficiency levels is largely a matter of self-assessment by the manufacturer of the product.

277. Feedback from stakeholders concerning compliance indicates that they are experiencing problems with interpreting and resolving ambiguities in the guidance.

278. For example, in the recent test of the switching lifetime of domestic light bulbs carried out by the National Measurement Office (NMO), the UK agency tasked with monitoring compliance with the Eco-design directive, the majority of bulbs failed to meet the 10,000 switching cycles threshold.

279. The NMO and the manufacturers disagreed about the interpretation of the 10 percent latitude granted for compliance, which the NMO took as meaning 90% of the lamps in a sample should meet the

87 http://ec. europa. eu/enterprise/policies/sustainable-business/ecodesign/product-groups/index_en. htm

standard, whereas the industry view was that the average of all samples in a batch had to be within 10 percent of the 10,000 switching cycles threshold.

280. An appeal was made to the European Commission, which decided that there was room for interpretation and that the industry's position was acceptable.[88] Issues of this sort will undoubtedly affect the accuracy of predictions of energy efficiency savings.

281. A survey of EU stakeholders found that 55% considered market surveillance by the authorities to be ineffective, with a large majority believing that enforcement of the Directive is not uniform across the EU. Some countries were felt to have much stronger market surveillance systems than others. Imports to the EU were also perceived as non-compliant.

282. Actual empirical testing is limited, but where it exists it reveals there is a shortfall in meeting the efficiency standards that need to be considered in making forward predictions of domestic savings.[89] For example, tests carried out by the NMO on refrigerators and freezers showed that four out of twelve models tested failed to comply, and one of those showed that the difference in energy consumption was equivalent to the difference between and A rating and a G rating. Similarly, testing by the Danish authorities found that compliance ranged from 82% for electric motors down to 50% for refrigerators and freezers.[90]

283. Also, inherent in realizing the costs savings predicted for the Products Policy is the requirement that consumers will be able to afford the upfront financial costs of buying the more efficient products, but these costs have not been included in DECC's modeling of costs and benefits of climate change policies in 2020.

284. It is also impossible to be certain how the public will use the more efficient products. For example, the energy efficient setting may not deliver performance satisfactory to the user, who may then elect to operate the appliance on a higher setting. For example, we have anecdotal evidence that a new A++ rated dishwasher is deemed by users to wash and dry inadequately on the reference economy setting so is operated in high temperature, extra-drying time mode. The energy consumption in this mode would be equivalent to an F rated machine.

Conclusions on the Product Policy

285. DECC's claim that there will be, on average, household savings of £158 per year attributable to more energy-efficient household appliances relies on an inflated savings value, namely the assumption that the value of a saved kWh in 2020 is 18p, whereas the cost of a kWh including Government's climate change policies is 14p.

286. Furthermore, even with this inflated savings price, the average household would need to reduce electricity consumption by 27% in 2020 by replacing existing household appliances with more energy efficient models. This implies appliance replacement on a very large scale in a short time.

287. However, the expense of appliance replacement is not taken into account in DECC's assessment of policy costs to the consumer.

288. The EU legislation setting the improved energy standards for appliances is proving slow to implement, monitoring of standards is sparse and enforcement of the standards is inconsistent across the EU countries. As a result of delay in agreeing EU standards, one third of DECC's predicted household savings is described as "uncertain" by DEFRA.

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88 For National Measurement Office testing of lamps see: http://www. bis. gov. uk/assets/nmo/docs/eup/domestic%20lighting%20project%20report%20november%202011. pdf

89 National Measurement Office, Enforcement Annual Report (2010–2011). See: http://www. bis. gov. uk/assets/nmo/docs/rohs/misc/enforcement%20end%20of%20year%20report%202010-2011%20cs. pdf

90 CSES report.

289. There is limited empirical evidence related to compliance and apparently none on how appliances are actually being used to confirm that they are being operated in the most energy efficient modes.

290. Overall, DECC's view that savings from more efficient appliances can provide the mainstay of policies to offset the costs of climate change policies is untenable. The hoped for savings are very unlikely to materialize in the quantities required by 2020.

8. Energy Efficiency Bibliography

The following list includes texts wholly or partly on energy efficiency and government policy related to these matters. All texts were consulted by REF while preparing the present study, though not all are cited.

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