




# Carbon taxes: which households gain or lose?

By

Sue Scott and John Eakins

Paper at ESRI Energy Policy Research Centre Conference:
The Sky's the Limit : Efficient and Fair Policies on Global Warming
11th December 2002

**The Economic and Social Research Institute**
**4 Burlington Road**
**Dublin 4**
Tel: (353-1) 667 1525
Fax: (353-1) 668 6231

# Carbon taxes: which households gain or lose? [1]

**By Sue Scott and John Eakins**[2]

INTRODUCTION

The purpose of this paper is to analyse the effects of the introduction of a carbon tax in order to see how it would affect different households. The paper focuses especially on vulnerable households, that is, households in low-income brackets and this exercise is undertaken with a view to providing suggestions for policies to alleviate any adverse effects.

The starting point is an assumption that the carbon tax would be imposed on fuels according to their emissions of carbon dioxide, and that the tax is levied at the rate of €20/tonne of $CO_2$. The tax would be imposed on fuels in the manner of excise taxes currently in operation and the effects of their imposition on the economy as a whole have already been outlined (Bergin, Fitz Gerald and Kearney, 2002). This paper proceeds to look into the detail at household level and investigates the first round effects, that is, the effects before taking into consideration the broad impacts on the economy of respending the revenues. The first round effects are the effects that are most 'visible' which, along with the effects on competitiveness, are the greatest cause for concern.

Another simplification in this paper is that the introduction of the carbon tax is assumed to be achieved in its entirety in year one, whereas in reality it would be phased in gradually with pre-announcement and preparation.

The discussion will proceed along the following lines. The first section looks at the direct impacts of the carbon tax on households in different income brackets and shows how these impacts are regressive, that is, they make low-income households relatively worse off than high-income households. Broad types of compensation strategies for addressing this problem are then briefly described in the next section. How to target vulnerable households is discussed in Section 3. In the fourth section, using the compensation strategy and targeting method selected, the net effects of the reform (the carbon tax net of compensation) are presented, enabling the gainers and the losers to be identified. The fifth section discusses other supporting measures that might be introduced to help losers and ease the transition to carbon taxes generally, and a concluding section follows.

[1] This research was funded as part of the Environmental Research, Technological Development and Innovation programme under the Productive Sector Operational Programme 2000-2006.The programme is financed by the Irish Government under the National Development Plan. It is administered on behalf of the Department of the Environment and Local Government by the Environmental Protection Agency which has the statutory function of co-ordinating and promoting environmental research.

[2] Sue Scott is a Senior Research Officer and at the time of working on this project John Eakins was a Research Assistant at the Economic and Social Research Institute.

1. IMPACTS

Having to hand the results of the Household Budget Survey (CSO, 2002) for 1999-2000, it is possible to describe household purchases of fuels and associated expenditure in considerable detail.[3] The accompanying information on household income enables us to categorise households in deciles of gross household income.[4] Chart 1 shows the annual quantities of fuels used, aggregated and converted to tonnes of oil equivalent (TOE), broken down by decile. (Fuels used in the generation of electricity are included.) The average household is also shown, on the right hand side. As expected, households in the higher income groups use more fuels. The fuels have been broken down into transport fuels and fuels used in the home, and the even stronger correspondence of quantities of transport fuels with higher incomes is striking. Associated with the use of these fuels are the emissions of carbon dioxide, shown in Chart 2.

**Chart 1. Average annual quantity of fuels used per household, TOE**

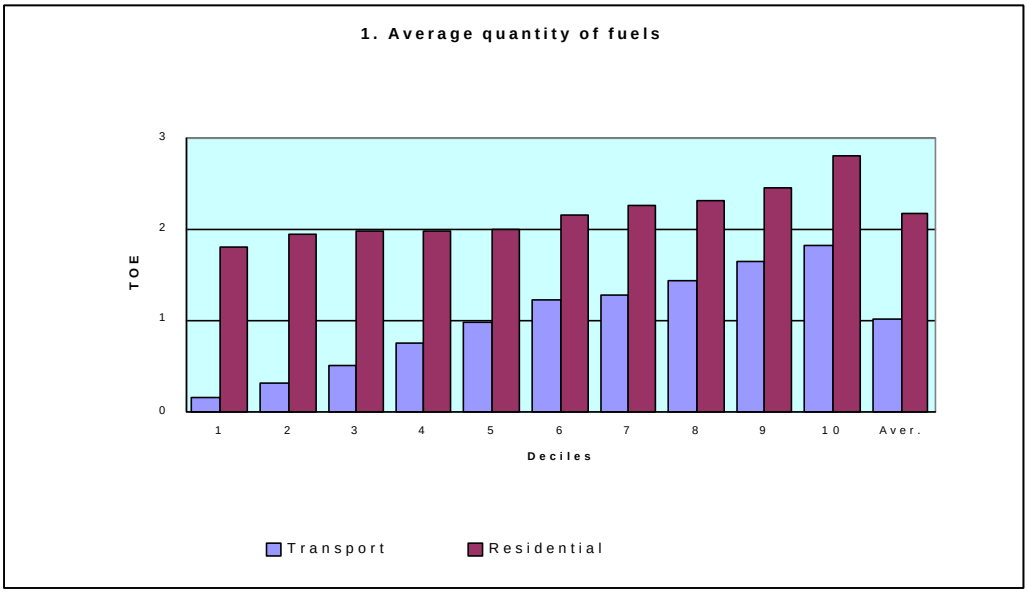
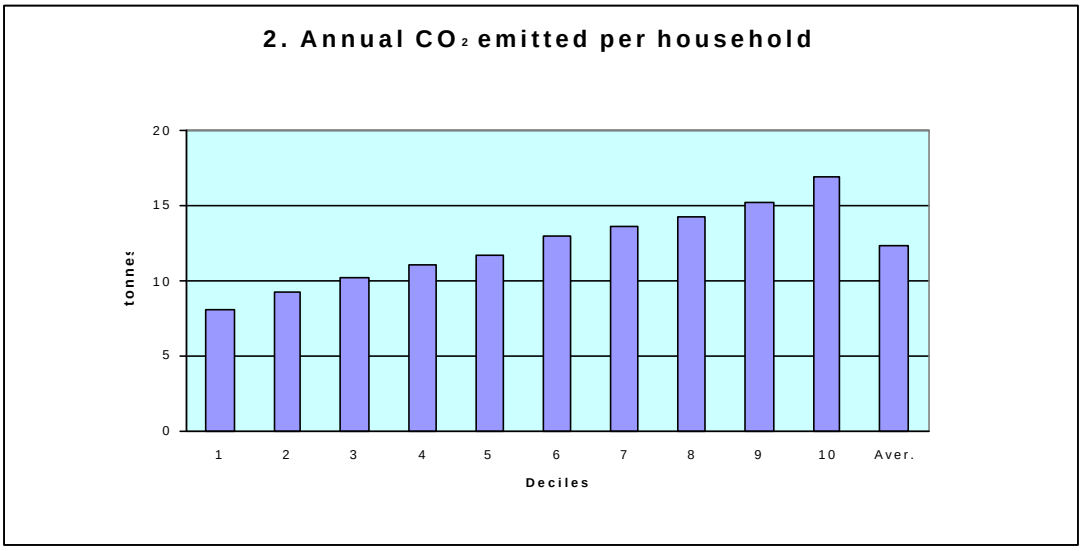



**Chart 2. Average annual emissions of carbon dioxide per household, tonnes**

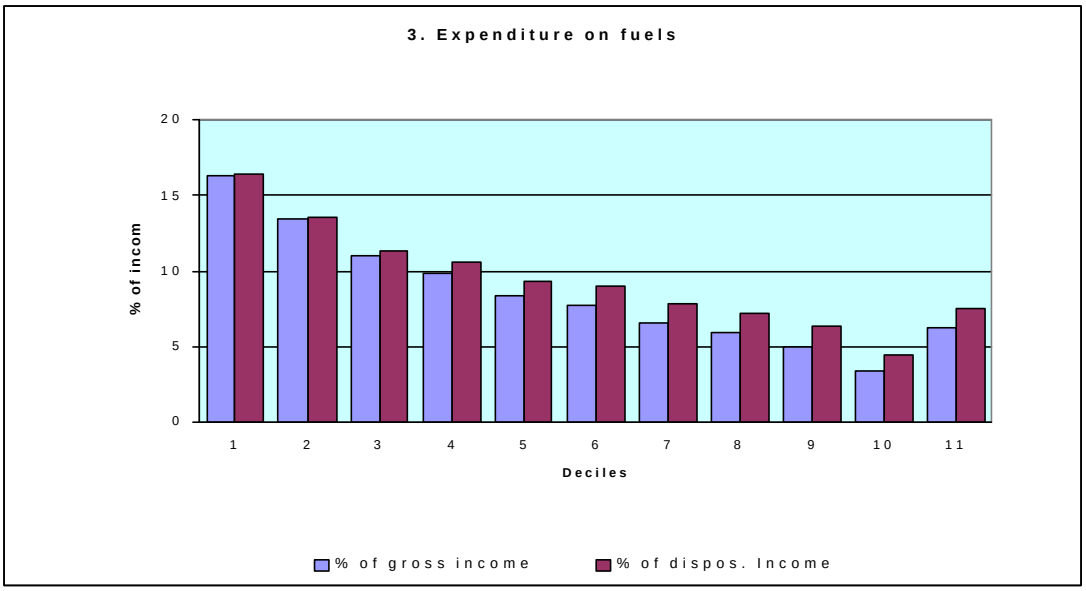
[3] The authors are grateful to the Central Statistics Office for providing the data file, in which household information has been rendered anonymous.

[4] Income deciles are constructed as follows. Households are ranked in ascending order of gross income. They are then divided in to ten even groups of households, the first group of households having the lowest incomes is called decile 1, the next group is decile 2 and so on.




Expenditure on fuels, expressed as a proportion of household income, is described in Chart 3, and it is the pattern shown here that drives this inquiry. As can be seen, expenditure on fuels forms a higher and sizeable share of the incomes of households in the lower deciles. When expenditure on fuels is expressed as a proportion of disposable income [5] (the second in each pair of bars) as opposed to gross income, the overall pattern is similar.

**Chart 3. Expenditure on fuels as a proportion of household income, %**

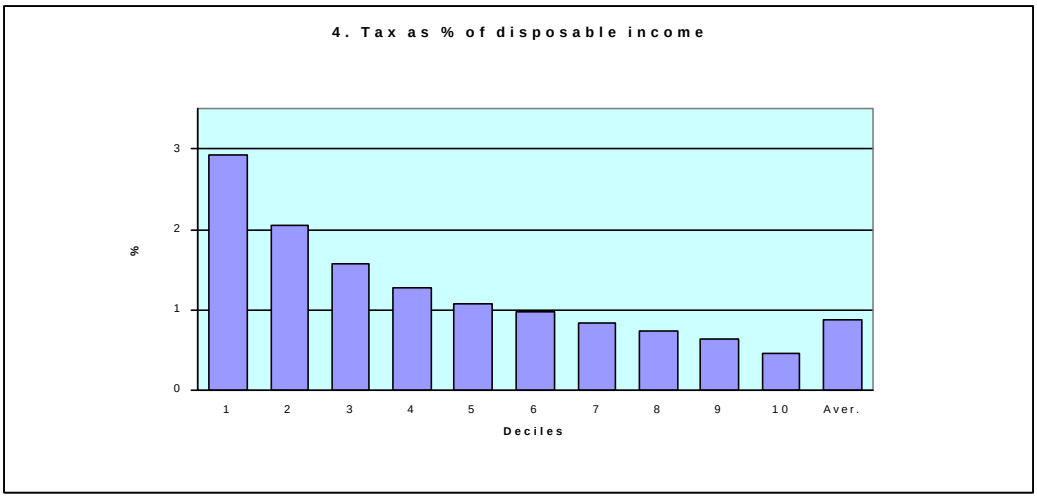



When the carbon tax is imposed, the result is even more regressive, as described in Chart 4. The carbon tax paid over a year by the average household is €247 and the tax paid by households in deciles 2 and 9, for example, is €186 and €304 respectively.

[5] Disposable income is gross income (direct income plus State transfers) after subtraction of direct taxation.

But when expressed as a proportion of their disposable incomes, the regressive nature of this tax is plain to see. Comparing deciles 2 and 9, the share of tax in decile 2 is some four times the share of tax in decile 9. This is steeper than the relative shares in the previous chart and it reflects the fact that the fuels used more intensively by low-income households tend to be the high emitters of carbon dioxide. High emitters are the solid fuels consisting mainly of coal, anthracite and turf. We see that for the thirty per cent of households in the three lowest deciles, the carbon tax would take over 1.5 per cent of their disposable income.

**Chart 4. Carbon tax as a proportion of disposable income, %**




As mentioned, only the first round effects are considered here and respending of revenues for macro-economic objectives is not taken into account. However it is worth pointing out that a previous study for Ireland, by Barker and Köhler (1998), modelled the outcome of recycling revenues as PRSI reductions as well as looking at the repercussions on income distribution. While the results showed that every decile's income increased, they also showed that the outcome was "weakly regressive" meaning that the improvements enjoyed by the poor were proportionately less than those enjoyed by the rich. Income inequality increased. Such a result suggests that it is low-income deciles that warrant attention. More importantly, there may also have been cases of hardship hidden by averaging at decile level.

Before discussing the types of strategy, it should be noted that any strategy ought to be 'energy neutral', that is, it should not distort decisions. For this reason, exemptions or free fuel schemes are not ideal and other compensation mechanisms should be sought.

## 2. STRATEGY

The design of a compensation strategy needs to keep several broad issues in mind. The first (positive) issue is that there is no shortage of funds available to ensure that

vulnerable households are protected. This is because the revenues from the carbon tax are very large. The second issue is that there are very real benefits to be derived by using the funds, in the manner described by Bergin *et al,* in order to remove distorting taxes in general and improve the functioning of the economy. Thirdly one wants to employ a compensation strategy that does not involve setting up a complicated administration and that targets vulnerable households without simultaneously giving windfall gains to households that do not need them.

It should be noted that we do not at this stage have the means for undertaking an exercise along the above lines in a fully integrated manner, using the SWITCH model, for example. However it is possible to look in detail at the first round effects of the carbon tax and apply a basic compensation strategy, to find useful indications.

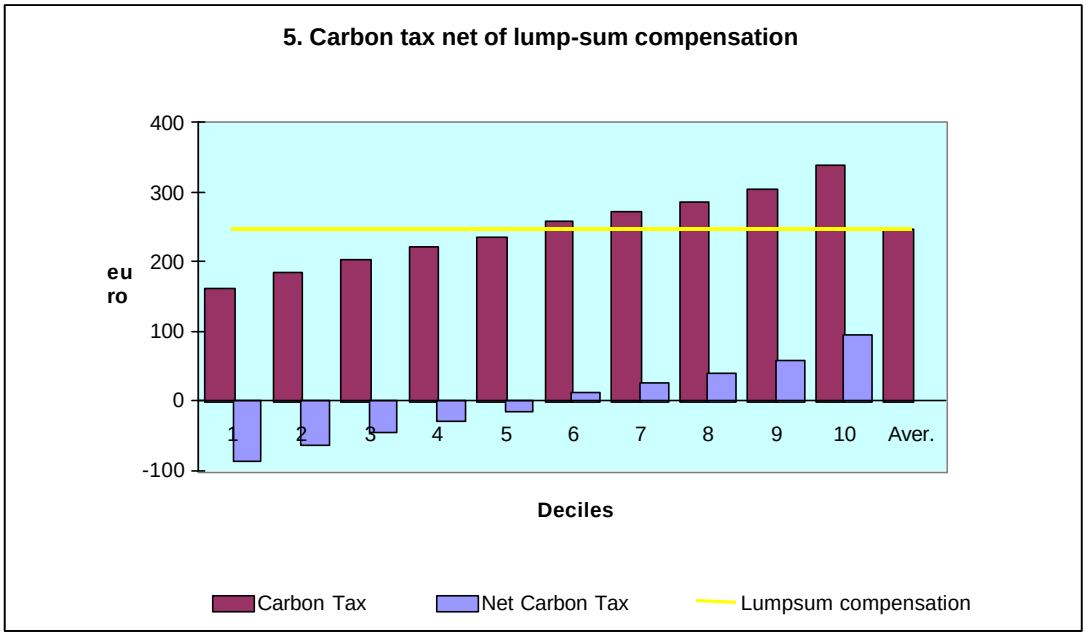
The compensation choices to hand discussed elsewhere already (Scott and Eakins, 2001), are broadly speaking: reforms to indirect and direct taxes, increases in social welfare provisions, subsidies to technical performance and other supportive measures like help-lines.

A lump-sum compensation strategy is often mentioned and has some appeal, and might operate through an extension to the income tax system. It takes the revenues from carbon taxes and simply returns them to households as a cash sum. Each household receives a lump-sum equivalent to the carbon paid by the average household. Setting aside such issues as household size and so forth, the appeal is that high emitters would be worse off, low emitters would be better off, so that the incentives to good environmental behaviour are correct and the funds paid by households match the funds received by households in total.[6] The appeal lies perhaps in the feeling that the earth's atmosphere belongs equally to everybody and that the revenue, arguably reflecting damage done, should therefore be distributed evenly.[7] An example of lump-sum compensation is shown in Chart 5 where the average revenue from households is redistributed. The lump-sum compensation of €247, shown by the flat line, is given to each household, like a cheque in the post for example. Taken in conjunction with the carbon tax, it leaves a net carbon tax, shown in the shorter bars, that leaves low-income households better off than before and high-income households worse off.

Chart 5. Carbon tax, lump-sum compensation and net carbon tax, € per household

[6] This option was investigated for the introduction of water services charges in *Green and bear it?* The recycling could, if wished, be made to reflect the economies of scale enjoyed by households with larger numbers of inhabitants. Such recycling would be facilitated were a system of refundable (or non-wastable) tax credits in place.

[7] In fact there is an argument in favour of dealing with this on a personal basis, rather than on a household basis, and work on 'adult equivalents' is in train. While more heat is required for larger households, there are economies of scale as the numbers in the household increase so that there is also a logic in concentrating on the household as the unit. However, compensation per person could have better incentive properties, depending on how it is applied.




The drawback of this strategy is that it would forego advantages to be derived from using the revenue in a general way to reduce some taxes that are distorting. As shown already by Barker and Köhler and now in more detail by Bergin *et al*, we can do better for society as a whole by using the revenue for implementing macro-economic reforms. But as stated, the earlier study also showed that better-off households would do relatively better and so we take this as our excuse to set them to one side and concentrate our attention on households in the lower income deciles.

A few magnitudes set out in Table 1 help to set the scene.

**Table 1. Possible compensation strategies and funds**

| STRATEGIES – Compensate households in deciles: | Compensation per household | Compensation sum[1] | Share of total carbon tax revenue[2] required |
|---|---|---|---|
| 1-5 by the average tax paid by deciles 1-5 | €201 | €136m | 16% |
| 1-5 by the overall average tax | €247 | €167m | 19.5% |
| 1-10 by the overall average tax | €247 | €333m | 39% |

[1] Assuming 1.350 million households in 2003 (Duffy *et al*, 2001)
[2] Assuming that total revenue from carbon taxes, including those imposed on industry et cetera, is €860 million (Bergin *et al, 2002)*

As shown in the first strategy in Table 1, the sum of tax paid by the lower five deciles amounts to €136 million, which is 16% of the revenue, and this could be used as the basis for a compensation strategy. However it would be difficult to compensate by amounts that would be close to the tax paid in individual cases, as there is no redistribution mechanism that is sufficiently discerning to do this. A large number of losers would result. A higher sum of revenue would be necessary to reduce the risks of widespread under-compensation.

The third strategy in Table 1 represents the lump-sum compensation already discussed. The middle strategy is the one on which our compensation strategy will be based. It amounts to compensating households in deciles 1-5 by €247 per year, at a total cost of €167 million or nearly 20 per cent of the total revenue from carbon taxes. It amounts to implementing a scheme akin to just the left-hand side of the lump-sum strategy described in Chart 5.

While the middle strategy chosen as a basis appears generous because the compensation of €247 to deciles 1-5 is greater than the carbon tax they pay as a group, €201, it is still less than the total sums that would need to be set aside. This is not only because of reasons of administration and targeting, but also to provide extra funding for schemes to help with house insulation and fuel switching.

It is therefore decided for the purpose of this exercise that the middle strategy will be investigated, and that extra funds will also be set aside for schemes. Thus a round figure of some €200 million of the €860 million revenue from carbon taxes is proposed to be set aside. This sum of €200 million represents about 23 per cent total revenue from carbon taxes and is assumed ear-marked for compensation and remedial measures. It leaves €660 million for use as efficient reforms, which in turn will also benefit deciles 1-5, though these benefits are not taken into account here.

## 3. TARGETING

The issue of how to target the compensation is now addressed. As mentioned, we concentrate on the options that use the main procedures that are already in place. These procedures consist of the various social welfare schemes and the income tax system.

There are many schemes in existence and the question is whether there is any particular scheme or combination of schemes that would be a simple vehicle for compensation. For example, possible targeting procedures could include households that are on low incomes that receive payments that qualify them for fuel allowances, and/or that are in possession of one or more Medical Cards, that receive Family Income Supplement and that receive Unemployment Benefit and so forth. Those that pay non-zero income tax are also targetable, through reductions in income tax.

Looking at some of these in more detail, it is found that there is no particular scheme already in existence that would target all households in income deciles 1-5. In theory the Medical Card might be used as a ‘passport’ to compensate for carbon taxes, but as this scheme becomes increasingly broadly targeted, its use is not recommended here.

Adding the compensation to fuel allowances (the National Fuel Scheme, paid in cash and not to be confused with the Free Fuel schemes) has obvious appeal. Fuel allowances help households which are dependent on long-term social welfare or health board payments and who are unable to provide for their own heating needs. Only one allowance is payable to any household. Eligibility involves a means test and includes receipt of certain other welfare payments. On checking through the ‘active’, i.e. non-zero, recipients of qualifying welfare payments, by using the data from the

Household Budget Survey, we see that some 60 per cent of households in deciles 1-5 would be covered. The 'fuel allowance qualifying' criterion and other possible targeting criteria are described in Table 2.

**Table 2. Qualifying criteria to target compensation to households[1] ('000 households)**

| Qualifying criteria – Households that: | Qualify (i.e. targetable) | Do not qualify | Total Households |
|---|---|---|---|
| 1. Receive benefits qualifying for fuel allowance | 465 | 756 | 1221 |
| of which: those in deciles 1-5 | 368 | 242 | 610 |
| | 60 % | 40 % | 100 % |
| 2. Receive all benefits[2] | 554 | 667 | 1221 |
| of which: those in deciles 1-5 | 415 | 195 | 610 |
| | 68 % | 32 % | 100 % |
| 3. Receive all benefits or are active tax-payers[3] | 1149 | 72 | 1221 |
| of which: those deciles 1-5 | 55 | 58 | 610 |
| | 91 % | 9 % | 100 % |

[1] All numbers are based on the HBS 1999-2000.

[2] Except Child Benefit, which is universal, all benefits listed in HBS are included (i.e. trl 459-481).

[3] We call these active tax-payers because they are those households with non-zero payment (of income tax plus social insurance contributions) entered in the HBS. The same means of selection has been applied to identify recipients of welfare benefits, that is recipients of non-zero amounts. The number of households in the tax system would be larger than the figures given here, which would improve potential coverage of households. This is because there are over 600,000 persons (note, persons not households) who are exempt tax but who are on the tax records.

The question is, can we target low-income households better and more comprehensively by including households that are recipients of any welfare benefits rather than just those qualifying for fuel allowances? The second row in Table 2, which incidentally excludes Child Benefit because they are not targeted at low-incomes, shows that the improvement with all benefits is not sizeable, as this brings the coverage of households in income deciles 1-5 up from 60 per cent merely to 68 per cent.

The third row in Table 2 shows that if households are selected that are actively in either the welfare net or tax net (including those in both) then coverage improves to 91 per cent. This is more promising. The tax route used for compensation would need to target the compensation carefully, by a judicious blend of thresholds and bands, to avoid compensating households other than those in the lower income deciles.

The nine per cent of households in deciles 1-5 in the third row that are not targetable may constitute a problem. The fact that they are not covered by social welfare schemes could mean that some do not qualify owing to the level of their assets or whatever,[8] or that they have slipped through the welfare net, which is not a problem

[8] For this reason some researchers, e.g. Conniffe (2000), classify households in the HBS by deciles of total household expenditure rather than by deciles of income. This route may be worth pursuing as it overcomes the fact that low-income deciles may include people who are temporarily receiving low income or who are not revealing their income from assets.

that can be easily addressed here. They might also consist of individuals such as students and so forth. We will leave aside these non-targetable cases at this stage.

## 4. COMPENSATION

To sum up so far, the strategy selected here is to compensate households in income deciles 1 to 5 by an amount equivalent to the all-households average carbon tax. In the calculations presented here, the compensation is targeted at all households that are actively in either the welfare net and/or income tax net.

The following assumptions are made. Compensation amounting to €247 annually is paid to each household that receives welfare benefits. Only one compensation per household is assumed given through the welfare system. For those households paying tax, compensation of €247 is assumed to be awarded through reductions in income tax. For those households that pay less than €247 in income tax and therefore cannot benefit fully from the reduction (which is likely in deciles 1 to 5), it is assumed that they are compensated to the extent that their tax payment allows.

With these compensation methods in operation, Table 3 shows stepwise the net carbon tax paid, that is, the tax net of compensation by households in income deciles 1 to 5. First the compensation is shown if only welfare recipients qualify. Next the compensation pattern is shown if only those households paying income tax qualify. Finally the compensation is shown if those that either receive welfare benefits and/or pay income tax qualify. In this option it is possible for some households to qualify twice and receive two sets of compensation. It might be possible to ensure that this did not happen but, for this exercise, administrative changes are assumed kept to a minimum.

**Table 3. Net carbon tax paid after compensation,[1] and coverage of households**

| | Household income deciles | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| *Households in the social welfare net:* | | | | | |
| Net carbon tax after compensation € | -88 | -64 | -39 | -33 | -15 |
| Coverage of households % | 86 % | 85 % | 72 % | 55 % | 43 % |
| *Households in the income tax net:* | | | | | |
| Net carbon tax after compensation € | 42 | 21 | -31 | -13 | -12 |
| Coverage of households % | 6 % | 14 % | 31 % | 63 % | 82 % |
| *Households in the social welfare and/or income tax nets:* | | | | | |
| Net carbon tax after compensation € | -84 | -71 | -73 | -92 | -93 |
| Coverage of households % | 90 % | 91 % | 88 % | 90 % | 94 % |

[1] Note that a negative tax indicates that the households are gainers after compensation.

Several observations are called for. Use of the social welfare net alone means that the share of households receiving compensation peters out rather strongly at deciles 4 and 5. As is to be expected, use of the income tax net alone is obviously unsatisfactory, in terms of coverage of the four lower deciles at least, and deciles 1 and 2 are not even

fully compensated since their net carbon tax is positive. Using the two systems combined provides rather good coverage and benefits, and this would be the targeting strategy to adopt. The disadvantage in its design is the high net benefit to the higher deciles, calling for more stringent application of compensation through the income tax system. This requires attention as there is serious risk of discontinuity after decile 5 and the potential harmful incentives that this could entail. It also goes without saying that special provisions would be required to be made for households where, for example, the medical condition of an inhabitant calls for unusually high levels of energy. There are some procedures in place for special cases but these may need to be enhanced.

The overall exchequer cost of the compensation strategies to help deciles 1 to 5 described so far is now considered. The cost of compensation through the social welfare system amounts to €103 million and the cost of the compensation via the tax system amounts to €54 million, bringing the overall cost to €157 million. This is to sum of €167 million derived initially in Table 1, and well short of the total €200 million, the final sum that was set aside for compensation and associated puposes.

*Gainers and losers*

Finally there is the important question as to whether there are still individual households among those that have been targeted who would lose out from the package. Does the above reporting where households are averaged at decile level conceal significant differences within decile? Do some households in deciles 1-5 use more energy than the all household average? The answer is a clear yes.

Table 4 shows the proportion of targeted households that would find themselves out of pocket, even after the having received the reasonably generous compensation of €247. Their numbers range from 16 per cent of those targeted in decile 1 up to 28 per cent of those targeted in decile 5. These households must be using a good deal of energy and it is worth investigating their characteristics.

**Table 4. Proportion of targeted households in each decile that are losers**

| | Household income deciles | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| Losers as % of targeted households | 16 % | 24 % | 25 % | 26 % | 28 % |

A comparison of the household characteristics of losers against gainers in each decile reveals a few differences but none that is striking. Losers tend to be more rural than urban and, in deciles 3 to 5, they comprise more farming households. Where household composition is concerned, fewer loser households consist of single persons and more consist of married couples and married couples plus 1 to 3 children. The nuber of inhabitants would therefore be somewhat larger. Compared with gainers, more ‘heads of household’ tend to be manual workers or farmers with less than 50 acres (or less than 100 acres in the 4$^{th}$ decile). Slightly more losers compared to gainers would have intermediate education as the last level of education completed. From decile 3 to 5 there are more owner-occupiers. These differences however are not marked.

It is when one looks at the method of heating that real differences emerge. For example in decile 1, among those using central heating, nearly 40 per cent of losers as against 20 per cent of gainers use solid fuel as their main heating method in winter. Among those not using central heating, the difference is less marked at 25 versus 20 per cent. This is a helpful result and gives a clear indication of where special policy measures could be directed.

A further point not alluded to as yet is the existence of households that use their own turf. Burning turf emits a heavy load of carbon dioxide. Use of turf by households that produce their own has been included in the analysis thus far. The quantity that they use is recorded in the HBS and a figure of their expenditure is imputed, by use of market prices. However, there would be little scope for imposing a carbon tax on these households, and in this respect, our estimated carbon tax paid is exaggerated. We do indeed find that 17 per cent of losers use their own turf with an imputed average expenditure of €9.73 or several cwt per week, all year round. This appears to be quite heavy usage and, if not exaggerated, may well account for some of the potential losers.

## 5. SUPPORTING MEASURES

Compensation is not the only policy measure to hand. There are several other potential supporting measures that would play an important role and for which, as was seen, there are adequate funds available. As many of the supporting measures have been described elsewhere they will only be outlined here.

The major advantage of the introduction, indeed the mere announcement, of carbon taxes is their encouragement to the many scientists and commercial enterprises that have been investigating energy saving technologies for the past few decades. The objective is to bring about changes in energy using technology and, as estimates of responsiveness to price hikes show, the response is bigger when people have had some time to respond.[9] In particular it takes time to get around to finding out about and getting round to improving the efficiency with which one uses energy. If schemes are put in place that improve the efficiency in the households in deciles 1 to 5 that we have investigated, this will provide a universal information spin-off to all that can be acted upon.

There are two aspects of efficiency improvement in particular that need to be addressed. One is the insulation of the houses, and the other is the heating systems used. The HBS data show that full or partial central heating is now installed in 73 per cent up to 93 per cent of deciles 1 and 5 respectively. If one looks at “main fuel used for heating in winter”, of those with full or partial central heating, 28 to 21 per cent rely on solid fuel. Of those without partial or central heating, 67 to 64 per cent rely on solid fuel. There is thus considerable scope for technical improvements.

Schemes have been investigated to help improve the housing stock and heating systems, including by Brophy *et al* (1999) in a report for Energy Action and by Healy

[9] E.g. Fitz Gerald *et al* (2002), Scott (1979, 1991).

(2002). Some 240,000 households are classified as energy inefficient (lacking 5 or more out of the 7 standard energy-saving features). A ten year programme to improve these would have sizeable benefits, not only the reduction in emissions per upgraded house of in the region of 2.6 tonnes of carbon dioxide per year.

Other supporting measures required would include help to Community Groups for town halls, churches, cultural venues and so forth.

Existing measures to preserve peatlands would need to be enhanced to tip the advantage away from burning turf as fuel, when the carbon tax is introduced.

Help-lines would be required for Social Welfare recipients, or potential recipients, to help them to obtain their entitlements. An enhanced domestic Energy Advice help-line, would be required to answer questions about domestic energy efficiency and on how to obtain reliable services.

The public transport subsidy would also require to be enhanced and focused on passenger numbers, rather than on diesel.

Technical improvement could be supported such as development of long overdue user-friendly controls on energy use, and meters and bills that are easily readable and give helpful information.

## 6. CONCLUSIONS

This paper investigated the options for compensating households in the low-income deciles in the event of the introduction of a carbon tax. A more integrated analysis of the tax and welfare systems would give more refined figures but, at this preliminary stage, answers to major questions can already be given.

Using data from the 1999-2000 Household Budget Survey, it was found that even with existing systems in place, by using the income tax and social welfare systems, some 90 per cent of households in income deciles 1 to 5 can be targeted for compensation.

Setting the level of compensation at the average of all households' carbon tax paid, amounts to compensating households to the tune of €247 per year.

At this level of compensation channelled through the social welfare system and/or through income tax reduction, households in all five income deciles gain, on average, from the reform.

However, within deciles there are losers and gainers. Some 84 per cent of targetable households in decile 1 would be gainers after the tax/compensation, and 72 per cent of households in decile 5. The losers correpondingly range from 16 per cent to 28 per cent of targetable households, depending on the decile. Losers would include those not on social welfare but paying insufficient tax to benefit from a tax reduction. They would also include households that use a lot of energy including those that use solid fuels. However those using their own turf may require special measures including incentives to reduce their extraction levels.

Schemes to help households to adapt the fabric of their homes and their energy using equipment would need to be put in place. Users of solid fuels would require help to switch to less carbon-intensive fuels. Community and cultural venues would also need assistance to upgrade the energy efficiency of their buildings. In the example used here there would be funds available for such programmes.

Other supportive measures would include help-lines to ensure that people obtain their compensation and domestic energy advice centres to impart technical information.

***References***


Barker, T. and J. Köhler, 1998. "Equity and Ecotax Reform in the EU: Achieving a 10 per cent Reduction in $CO_2$ Emissions Using Excise Duties", *Fiscal Studies,* Vol. 19, no. 4, pp. 375-402

Bergin, A., J. Fitz Gerald and I Kearney, 2002. "The Macro-economic Effects of Using Taxes or Emissions Trading Permits to Reduce Greenhouse Gas Emissions" paper read at ESRI conference: *The sky's the limit - Efficient and fair policies on global warming*

Brophy, V., Clinch, J.P., Convery, F.J., Healy, J.D., King, C. and Lewis, J.O. (1999). *Homes for the 21st Century: The Costs & Benefits of Comfortable Housing in Ireland.* Report prepared by Energy Research Group and Environmental Institute, UCD, for Energy Action Ltd: Dublin.

Conniffe, D., 2000. "The free electricity allowance and the Engel curve", *The Economic and Social Review,* vol. 31 no. 2, April

Duffy, D. J. Fitz Gerald, J. Hore and I. Kearney, 2001. Medium-Term Review. ESRI.

Fitz Gerald, J., J. Hore and I. Kearney, 2002. *A Model for Forecasting Energy Demand and Greenhouse Gas Emissions in Ireland.* Working paper No 146. Economic and Social Research Institute. Dublin

Healy, J., 2002. *Domestic Energy Efficiency, Fuel Poverty and health: A Pan-European Analysis.* Unpublished Ph.D. Thesis, Department of Environmental Studies, UCD

Scott, S. 1980. *Energy Demand in Ireland, Projections and Policy Issues.* PRS no. 2. Economic and Social Research Institute. Dublin

Scott, S., 1991. *Domestic Electricity Demand,* GRS no 151. Economic and Social Research Institute. Dublin

Scott, S. 2002. "Environmental fiscal Reform and Income Distribution Concerns in Relation to Ireland", paper to OECD Conference: *Environmental Fiscal Reform,* Berlin , June.

## Appendix Table 1. Conversions and emission factors

| HBS Fuels | HBS Units | Conversions TOE per unit | Emission factors* tCO2/TOE |
|---|---|---|---|
| Gas | kWh | 0.000086 | 2.300 |
| Electricity | kWh | 0.000086 | 8.785 |
| Anthracite | kgs | 0.000700 | 4.110 |
| Coal | kgs | 0.000665 | 3.960 |
| Turf loose | cwt | 0.015900 | 4.340 |
| Turf briquettes | bales | 0.005538 | 4.140 |
| Central heating oil | litres | 0.000868 | 3.050 |
| Paraffin oil | pints | 0.000473 | 2.980 |
| Liquid Petroleum Gas | kgs | 0.001126 | 2.670 |
| Motor Fuel: Petrol | litres' | 0.000794 | 2.990 |
| Motor Fuel: Diesel | litres' | 0.000868 | 3.050 |
| Motor Fuel: LPG auto | litres' | 0.000579 | 2.670 |

* For electricity, the fuels for generation are included.

' Expressed in euro in the HBS

**Appendix Table 2. Household weekly expenditure on fuels (euro)**

| | Deciles of Gross Household Income | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1st | 2nd | 3rd | 4th | 5th | 6th | 7th | 8th | 9th | 10th | Average |
| | ≤ €132.08 | ≤ €214.46 | ≤ €306.03 | ≤ €411.89 | ≤ €531.57 | ≤ €664.60 | ≤ €810.95 | ≤ €1016.84 | ≤ €1339.34 | > €1339.34 | |
| Fuel | | | | | | | | | | | Household |
| Gas | 1.501 | 2.022 | 1.884 | 2.131 | 2.714 | 3.096 | 3.597 | 3.458 | 4.630 | 5.972 | 3.100 |
| Electricity | 4.133 | 6.065 | 7.207 | 8.494 | 8.771 | 9.931 | 10.054 | 11.294 | 10.838 | 12.400 | 8.919 |
| Anthracite | 0.056 | 0.087 | 0.062 | 0.070 | 0.044 | 0.040 | 0.055 | 0.093 | 0.098 | 0.093 | 0.070 |
| Coal and Coke | 3.136 | 3.162 | 2.922 | 3.198 | 2.545 | 2.187 | 2.257 | 1.832 | 1.566 | 1.402 | 2.421 |
| Peat Briquettes | 1.014 | 0.666 | 0.736 | 0.458 | 0.506 | 0.318 | 0.451 | 0.653 | 0.488 | 0.583 | 0.587 |
| Turf | 0.928 | 1.358 | 1.152 | 0.883 | 1.006 | 0.873 | 0.828 | 0.809 | 0.717 | 0.463 | 0.902 |
| Central Heating Oil | 2.397 | 2.682 | 3.094 | 3.851 | 3.927 | 4.776 | 4.671 | 5.688 | 5.881 | 6.284 | 4.325 |
| Paraffin Oil | 0.016 | 0.013 | 0.000 | 0.067 | 0.001 | 0.041 | 0.001 | 0.031 | 0.072 | 0.091 | 0.033 |
| Liquid Petroleum Gas | 0.842 | 1.014 | 0.870 | 0.651 | 0.563 | 0.741 | 0.707 | 0.553 | 0.701 | 0.345 | 0.699 |
| Wood and Kindling | 0.390 | 0.180 | 0.286 | 0.193 | 0.135 | 0.055 | 0.209 | 0.334 | 0.093 | 0.117 | 0.199 |
| Motor Fuel: Petrol | 2.782 | 5.647 | 8.662 | 12.925 | 15.862 | 19.042 | 21.396 | 24.733 | 28.166 | 32.123 | 17.133 |
| Motor Fuel: Diesel | 0.285 | 0.698 | 1.479 | 1.997 | 3.223 | 5.042 | 4.060 | 3.814 | 4.808 | 4.178 | 2.958 |
| Motor Fuel: LPG auto | 0.000 | 0.000 | 0.000 | 0.001 | 0.057 | 0.000 | 0.000 | 0.000 | 0.009 | 0.000 | 0.007 |
| | | | | | | | | | | | 41.353 |
| Expenditure on all fuels | 17.479 | 23.594 | 28.354 | 34.918 | 39.355 | 46.143 | 48.287 | 53.292 | 58.066 | 64.051 | 41.353 |
| Gross income of household | 107.230869 | 175.80444 | 256.4431 | 354.6654526 | 472.04597 | 598.18521 | 732.45238 | 906.4595663 | 1161.44565 | 1901.060 | 666.720 |
| % of gross income | 16.300 | 13.420 | 11.057 | 9.845 | 8.337 | 7.714 | 6.592 | 5.879 | 4.999 | 3.369 | 6.202 |
| Disposable income of househ. | 106.406369 | 174.39625 | 249.33847 | 331.929399 | 422.93755 | 515.63918 | 618.84839 | 743.8882095 | 925.090976 | 1428.710 | 551.600 |
| % of dispos. Income | 16.427 | 13.529 | 11.372 | 10.520 | 9.305 | 8.949 | 7.803 | 7.164 | 6.277 | 4.483 | 7.497 |

Appendix Table 3. Household weekly quantities of fuels in HBS units

| | | Deciles of Gross Household Income | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | HBS | 1st | 2nd | 3rd | 4th | 5th | 6th | 7th | 8th | 9th | 10th | State |
| | | ≤ €132.08 | ≤ €214.46 | ≤ €306.03 | ≤ €411.89 | ≤ €531.57 | ≤ €664.60 | ≤ €810.95 | ≤ €1016.84 | ≤ €1339.34 | > €1339.34 | |
| Fuel | Units | | | | | | | | | | | Average |
| Gas | kWh | 45.220 | 55.280 | 58.029 | 55.588 | 77.392 | 89.138 | 104.534 | 100.616 | 138.606 | 184.366 | 90.871 |
| Electricity | kWh | 43.938 | 58.440 | 70.952 | 81.328 | 84.365 | 91.810 | 95.800 | 103.123 | 102.162 | 120.285 | 85.219 |
| Anthracite | kgs | 0.219 | 0.581 | 0.242 | 0.260 | 0.163 | 0.107 | 0.187 | 0.345 | 0.456 | 0.278 | 0.284 |
| Coal | kgs | 13.312 | 13.175 | 12.673 | 13.278 | 9.690 | 9.205 | 9.309 | 7.634 | 7.178 | 5.969 | 10.142 |
| Turf loose | cwt | 0.536 | 0.525 | 0.460 | 0.333 | 0.379 | 0.325 | 0.379 | 0.284 | 0.278 | 0.252 | 0.375 |
| Turf briquettes | bales | 0.514 | 0.347 | 0.350 | 0.254 | 0.237 | 0.182 | 0.219 | 0.326 | 0.195 | 0.292 | 0.291 |
| Central heating oil | litres | 7.052 | 8.426 | 9.714 | 11.628 | 11.741 | 14.842 | 13.840 | 16.942 | 17.477 | 19.980 | 13.164 |
| Paraffin oil | pints | 0.046 | 0.028 | 0.000 | 0.210 | 0.003 | 0.112 | 0.000 | 0.100 | 0.324 | 0.286 | 0.111 |
| Liquid Petroleum Gas | kgs | 0.610 | 0.703 | 0.642 | 0.455 | 0.423 | 0.593 | 0.548 | 0.534 | 0.660 | 0.342 | 0.551 |
| Motor Fuel: Petrol | litres' | 3.304 | 6.707 | 10.287 | 15.350 | 18.839 | 22.615 | 25.410 | 29.374 | 33.451 | 38.150 | 20.348 |
| Motor Fuel: Diesel | litres' | 0.364 | 0.894 | 1.892 | 2.555 | 4.124 | 6.451 | 5.195 | 4.879 | 6.151 | 5.345 | 3.785 |
| Motor Fuel: LPG auto | litres' | 0.000 | 0.000 | 0.000 | 0.002 | 0.108 | 0.000 | 0.000 | 0.000 | 0.016 | 0.000 | 0.013 |

' Expressed in euro in the HBS

Appendix Table 4. Household weekly quanitities of fuels in TOE

| | Deciles of Gross Household Income | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1st | 2nd | 3rd | 4th | 5th | 6th | 7th | 8th | 9th | 10th | Avarage |
| | ≤ €132.08 | ≤ €214.46 | ≤ €306.03 | ≤ €411.89 | ≤ €531.57 | ≤ €664.60 | ≤ €810.95 | ≤ €1016.84 | ≤ €1339.34 | > €1339.34 | |
| Fuel | | | | | | | | | | | household |
| Gas | 0.0039 | 0.0048 | 0.0050 | 0.0048 | 0.0067 | 0.0077 | 0.0090 | 0.0087 | 0.0119 | 0.0159 | 0.0078 |
| Electricity | 0.0038 | 0.0050 | 0.0061 | 0.0070 | 0.0073 | 0.0079 | 0.0082 | 0.0089 | 0.0088 | 0.0103 | 0.0073 |
| Anthracite | 0.0002 | 0.0004 | 0.0002 | 0.0002 | 0.0001 | 0.0001 | 0.0001 | 0.0002 | 0.0003 | 0.0002 | 0.0002 |
| Coal | 0.0089 | 0.0088 | 0.0084 | 0.0088 | 0.0064 | 0.0061 | 0.0062 | 0.0051 | 0.0048 | 0.0040 | 0.0067 |
| Turf loose | 0.0085 | 0.0084 | 0.0073 | 0.0053 | 0.0060 | 0.0052 | 0.0060 | 0.0045 | 0.0044 | 0.0040 | 0.0060 |
| Turf briquettes | 0.0028 | 0.0019 | 0.0019 | 0.0014 | 0.0013 | 0.0010 | 0.0012 | 0.0018 | 0.0011 | 0.0016 | 0.0016 |
| Central heating oil | 0.0061 | 0.0073 | 0.0084 | 0.0101 | 0.0102 | 0.0129 | 0.0120 | 0.0147 | 0.0152 | 0.0173 | 0.0114 |
| Paraffin oil | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0000 | 0.0001 | 0.0000 | 0.0000 | 0.0002 | 0.0001 | 0.0001 |
| Liquid Petroleum Gas | 0.0007 | 0.0008 | 0.0007 | 0.0005 | 0.0005 | 0.0007 | 0.0006 | 0.0006 | 0.0007 | 0.0004 | 0.0006 |
| Motor Fuel: Petrol | 0.0026 | 0.0053 | 0.0082 | 0.0122 | 0.0150 | 0.0180 | 0.0202 | 0.0233 | 0.0266 | 0.0303 | 0.0162 |
| Motor Fuel: Diesel | 0.0003 | 0.0008 | 0.0016 | 0.0022 | 0.0036 | 0.0056 | 0.0045 | 0.0042 | 0.0053 | 0.0046 | 0.0033 |
| Motor Fuel: LPG auto | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Total TOE | 0.0378 | 0.0434 | 0.0479 | 0.0526 | 0.0571 | 0.0651 | 0.0681 | 0.0721 | 0.0793 | 0.0888 | 0.0612 |
| Total TOE excl transport | 0.0349 | 0.0373 | 0.0381 | 0.0382 | 0.0385 | 0.0415 | 0.0434 | 0.0445 | 0.0474 | 0.0538 | 0.0418 |
| Total transp TOE Transport | 0.0029 | 0.0061 | 0.0098 | 0.0144 | 0.0186 | 0.0236 | 0.0247 | 0.0276 | 0.0319 | 0.0349 | 0.0195 |
| Total TOE excl transpo Residenti | 0.0349 | 0.0373 | 0.0381 | 0.0382 | 0.0385 | 0.0415 | 0.0434 | 0.0445 | 0.0474 | 0.0538 | 0.0418 |

Appendix Table 5. Household weekly tonnes CO2 emitted

| | Deciles of Gross Household Income | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1st | 2nd | 3rd | 4th | 5th | 6th | 7th | 8th | 9th | 10th | Average |
| Fuel | ≤ €132.08 | ≤ €214.46 | ≤ €306.03 | ≤ €411.89 | ≤ €531.57 | ≤ €664.60 | ≤ €810.95 | ≤ €1016.84 | ≤ €1339.34 | > €1339.34 | household |
| Gas | 0.00894443 | 0.0109344 | 0.0114782 | 0.010995396 | 0.0153081 | 0.0176316 | 0.0206768 | 0.019901858 | 0.02741618 | 0.03646759 | 0.0179743 |
| Electricity | 0.03319536 | 0.0441517 | 0.0536041 | 0.061443075 | 0.0637378 | 0.0693625 | 0.0723773 | 0.077909197 | 0.07718326 | 0.09087564 | 0.0643834 |
| Anthracite | 0.00063063 | 0.0016724 | 0.0006966 | 0.000748277 | 0.0004699 | 0.0003068 | 0.0005381 | 0.000993986 | 0.00131171 | 0.00079917 | 0.0008167 |
| Coal | 0.03505501 | 0.0346939 | 0.0333732 | 0.034965663 | 0.025518 | 0.0242405 | 0.0245135 | 0.020103874 | 0.01890242 | 0.01571934 | 0.0267082 |
| Turf loose | 0.03701862 | 0.0362532 | 0.0317593 | 0.022979169 | 0.0261817 | 0.0224265 | 0.0261873 | 0.019612743 | 0.01919594 | 0.01738714 | 0.0258997 |
| Turf briquettes | 0.01178631 | 0.0079554 | 0.0080206 | 0.005833554 | 0.0054323 | 0.0041682 | 0.0050094 | 0.007462586 | 0.00446433 | 0.00669144 | 0.0066823 |
| Central heating oil | 0.01866327 | 0.0222988 | 0.025706 | 0.030771314 | 0.0310706 | 0.0392791 | 0.0366264 | 0.04483511 | 0.04625001 | 0.05287525 | 0.0348376 |
| Paraffin oil | 6.4783E-05 | 3.964E-05 | 0 | 0.000295356 | 4.059E-06 | 0.0001578 | 6.546E-07 | 0.000140634 | 0.00045703 | 0.0004032 | 0.0001563 |
| Liquid Petroleum Gas | 0.0018344 | 0.0021143 | 0.0019303 | 0.001369475 | 0.0012713 | 0.0017824 | 0.0016481 | 0.001606939 | 0.00198429 | 0.00102726 | 0.0016568 |
| Motor Fuel: Petrol | 0.00784681 | 0.0159265 | 0.0244267 | 0.036449522 | 0.0447341 | 0.0537024 | 0.0603384 | 0.069751853 | 0.07943244 | 0.090591 | 0.0483179 |
| Motor Fuel: Diesel | 0.00096444 | 0.0023646 | 0.0050069 | 0.006761004 | 0.0109131 | 0.0170723 | 0.0137479 | 0.012912533 | 0.01627745 | 0.01414428 | 0.0100168 |
| Motor Fuel: LPG auto | 0 | 0 | 0 | 2.8744E-06 | 0.0001671 | 0 | 0 | 0 | 2.5027E-05 | 0 | 1.952E-05 |
| Total weekly tonnes CO2 | 0.15600406 | 0.1784049 | 0.1960019 | 0.21261468 | 0.2248079 | 0.2501299 | 0.2616638 | 0.275231313 | 0.29290007 | 0.32698131 | 0.2374697 |
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Aver. |
| Annual tonnes CO2 | 8.11221114 | 9.2770545 | 10.192097 | 11.05596335 | 11.69001 | 13.006755 | 13.606517 | 14.31202829 | 15.2308038 | 17.003028 | 12.348423 |