The distributional impact of the Irish public service obligation levy on electricity consumption

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Abstract

We analyse the distributional impact of financing renewable energy policies via levies on domestic consumption, focussing on Ireland's flat-rate public service obligation (PSO) levy. We find that switching Ireland's flate-rate charge to a unit-based regime results in a trend of reduced regressivity across the entire income distribution. A disproportionately large amount of high electricity users in the first income decile results in PSO burden increasing for these households. Incremental block-based levy structures exaggerate both effects. A hybrid fixed/variable tariff structure mitigates regressivity for high users but overall regressivity reduction is less. Social transfer schemes retain distributional benefits whilst minimising regressivity amongst high electricity users. We show that social transfer via Ireland's Household Benefits Package is sub-optimal and an equivalised income-based measure is more effective in addressing regressivity amongst low earners. Net of 'merit order' savings, flat charges redistribute burden incidence from rich to poor whilst fixed per-unit charges have a neutral effect. Incremental unit-based charges shift total cost to heavy users, predominantly comprised of large households. This results in a negative net burden for the majority of households across all income groups.

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1 Introduction

Achieving goals of environmental sustainability and security of supply in the provision of electricity generation often requires public subsidy (Doherty and O'Malley, 2011; Krozer, 2013). Ireland, like many other coutnries, finances these subsidies through an electricity consumer-levied PSO levy. The total public liability is apportioned amongst three classes of electricity user; residential, small commercial and medium/large electricity users (CER, 2013). A greater subsidy is required should there be an increase in the quantity of installed renewable generation. Subsidising renewables with no marginal cost, such as wind, may also affect electricity prices. As wind generation has no marginal cost, and as wholesale electricity prices are determined by marginal cost, the resultant displacement of conventional generation may cause wholesale prices to fall (Sensfuß et al., 2008). Clifford and Clancy (2011) have found that in Ireland to date, these counteracting effects cancel each other out and give a net impact close to zero.

Such change does not affect the aggregate cost of electricity but a compositional change is taking place. As more wind enters the generation mix, a greater share of each consumer's electricity bill is being comprised of the PSO charge as opposed to the usage cost. Should suppliers pass on savings in the wholesale market to consumers, the per-unit cost of electricity for each consumer may decrease. However, the subsidy required may increase and the means by which this cost is imposed on each consumer becomes more important. If, as is the case in Ireland, the PSO charge were a flat rate charge, a greater proportion of each consumer's electricity cost is being comprised of a fixed PSO charge, as opposed to a variable per unit-based charge. This may comprise a larger share of a poorer consumer's budget.

These distributional impacts are of particular relevance following recent Irish policy developments. Budget 2013 (Department of Social Protection, 2013) has changed the free electricity allowance available under the 'Household Benefits Package' (HBP) from being allocated on a 'unit + PSO'-based allowance to a fixed monetary allowance. This change has been motivated on the grounds of encouraging competition (Department of Social Protection, 2013), as beneficiaries have an incentive to source electricity at least cost. However, the budget constraints of HBP beneficiaries are now exposed to changes in the PSO levy. This impact is of increasing relevance as the Irish PSO has risen in recent years (see, for example, CER, 2009, 2013).

Given these factors, the social implications of potential PSO levy designs is of considerable

Abbreviations: DCENR: Department of Communications, Energy and Natural Resources; DSP: Department of Social Protection; FiT: Feed-in Tariff; HBP: Household Benefits Package; HBS: Household Budget Survey; IBP: Incremental Block Pricing; kWh: Kilowatt Hour; MW: Megawatt; REFIT: Renewable Energy Feed-in Tariff; PSO: Public Service Obligation (levy); SEM: Single Electricity Market.

importance. These impacts are considered alone and alongside the distribution of cost savings due to wind deployment. This framework will also be used to analyse recent changes in Irish welfare policy and the potential impact this may have in reducing some of the negative factors associated with considered tariff designs. In carrying out these goals, this paper is structured as follows. The following section will review the literature to date. Section 3 outlines the data and methodology used. Section 5 will discuss the distribution of cost whilst Section 7 will discuss the distribution of cost net of wholesale price reduction. Section 8 offers some concluding comments.

2 Motivation and Literature

Neuhoff et al. (2013) have noted that sustainable energy policy requires assessment of social implications and 'necessary measures to address hardship'. Much of the literature analysing such social implications has focussed on aggregate impacts. Devitt and Malaguzzi Valeri (2011) have quantified the aggregate Irish subsidy required to meet a number of renewable energy deployment scenarios, identifying the potential change in subsidisation cost under different fuel and deployment targets. Clifford and Clancy (2011) carried out a more recent analysis in a similar vein to Devitt and Malaguzzi Valeri (2011) but focussed on the cost of deployment for 2011. They find that the addition of wind resulted in the gross cost of electricity in the Irish republic to fall by approximately €74 million; aggregate subsidies total approximately €50m; whilst increased constraint costs approximate the difference between reduced wholesale and increased subsidy costs. Overall, Clifford and Clancy (2011) found that the reduced market costs of electricity in Ireland in 2011, net of incurred constraint costs, corresponded roughly to the aggregate cost of wind subsidy. Whether this balance will prevail in the future is uncertain. Devitt and Malaguzzi Valeri (2011) and Clifford et al. (2013) illustrate that the net impact on electricity cost is dependent on the fuel scenario assumed. Clifford et al. (2013) show that there will be a net increase in cost with an increase in capacity should 'low' or 'median' price scenarios prevail, with a small net cost or a net benefit should high cost scenarios prevail.

These aggregate impacts have not been explicitly disaggregated to the household level in the literature to date, although a number of analyses have looked at elements of these and similar payments in isolation. Chawla and Pollitt (2013) have analysed the distribution of cost to support energy efficiency and environmental policies in the UK. They find that the proportional cost has risen in recent years, with a disproportional burden on low-income households. Neuhoff et al. (2013) analyse the distributional impact of the German energy transition at the household level and consider the effect that a number of policy options may have on mitigating the regressivity of resultant impacts. Grösche and Schröder (2011) consider the redistributional impact of Germany's equivalent levy, the EEG levy, on income inequality net of solar PV ownership, finding that inequality rises marginally and the scheme is mildly regressive. Verde and Pazienza (2013) analyse the distribution of the Italian equivalent of the Irish PSO, the A3 surcharge. The socioeconomic distribution of this cost is considered relative to financing these policies by means of a carbon tax, whereby a carbon tax is found to be less regressive. Although focussing on charging schemes for general energy consumption as opposed to particular levies, Borenstein (2012) and Borenstein and Davis (2012) analyse the distributional impact and deadweight loss of different electricity and gas pricing structures.

Studies such as that of Neuhoff et al. (2013), Chawla and Pollitt (2013) and Verde and Pazienza (2013) have contributed towards the distributional understanding of German and UK energy policies. This paper adds to these contributions by analysing the the distribution of existing Irish policy. This is carried out alongside a distributional analysis of changing Irish policy by expanding the analysis of Verde and Pazienza (2013) to give insight into further alternative levy structures. The distributional impact of social transfers is also analysed in this paper. This analysis is in a similar vein to that of Neuhoff et al. (2013) in that past and prospective alternate options are considered. However, explicit attention is paid to quantifying the distributional impact of such measures.

As this review has illustrated, the existing literature analysing the distribution of cost to support energy and environmental policy has either focussed on aggregate impacts (e.g. Devitt and Malaguzzi Valeri, 2011; Clifford and Clancy, 2011) or has concentrated on the equity of cost distribution alone. Grösche and Schröder (2011) provide the closest contribution by analysing the net redistributive effect of solar PV subsidy, but do not consider any 'merit order' effect on wholesale prices. This is an important consideration for energy and environmental policies that affect the price of electricity. Indeed, addressing this gap is especially important from an Irish policy context as the incidence of cost differs from the incidence of savings. The importance of this contribution may be made clearer by drawing on the findings of Clifford et al. (2013). To meet Ireland's 40% renewables target in 2020, they find that REFIT cost may increase by 210-450%, whilst the change in aggregate electricity cost may range from +14.0% to -3.2%. Regardless of the scenario chosen, the PSO levy will potentially comprise a non-trivial portion of electricity expenditure and thus the structure of the PSO charge will become an increasingly important factor as deployment progresses to achieve Ireland's 40% target. Indeed, such a trend is evident in an international context, with the equivalent German mechanism, the EEG levy, comprising approximately 18% of household electricity cost in 2013, potentially growing to 21% in 2014 (Bryant, 2013; DW, 2013). The findings of this analysis may inform the policy debate in jurisdictions such as this where the cost of subsidisation is of similar importance.

3 Methodology and Data

3.1 Wholesale Electricity Price and PSO Levy

The methodology of this paper proceeds in a number of stages. First, we must calculate the aggregate PSO cost and impact wind has had on wholesale electricity pricess. Discussed in section 2, parameter values are taken from Clifford and Clancy (2011). As the distributional impact is of primary concern in this paper, a single scenario is chosen. This is a central scenario with a scale of installation and assumed energy prices of similar magnitude to those in Ireland in 2011. In such a scenario, the costs and benefits of wind cancel each other out. The paramaters employed for this study are outlined in Table 1.

Table 1: REFIT portion of PSO Cost per household

Parameter	Value (€)
Aggregate REFIT requirement	50,000,000
Domestic proportion	21,500,000
Annual REFIT PSO cost per household	10.591
Weekly REFIT PSO cost per household (flat rate)	0.2031

These aggregate changes in wholesale electricity price must then be disaggregated to the household level. The anonymised 2009/2010 Household Budget Survey (Central Statistics Office, 2012) is the primary dataset used for this purpose. The 2009/2010 HBS contains a representative random sample of 5,891 private households with a response rate of just under 40% (Central Statistics Office, 2012). Responses are weighted to minimise any bias that may occur due to participant non-response. The HBS details household-level socio-economic characteristics, income and itemized weekly expenditures which specify the cost of total electricity consumed. From these data, quantities of electricity per household may be derived using standing charges and prices paid during the survey period of 2009/2010[3] (CER, 2010b, 2011b).

Calculation of the household-level PSO cost required for wind subsidy is carried out as follows. In Ireland, electricity users are delineated according to domestic consumers, small commercial consumers, and medium/large consumers. Total wind subsidies are calculated by the Commission

[3]It should be noted that during this period, ESB Customer Supply, Bord Gais and Airtricity operated in the retail electricity market for domestic consumers. The vast majority of customers (80% in Q4 2009, falling to 68% at end Q3 2010) were served by ESB Customer Supply (CER, 2010b, 2011b). The HBS does not contain data on supplier or billing structure faced by each household. Given the dominance of ESB Customer Supply during this period, it is assumed that each consumer is an ESB customer. Further, customers may choose either a standard tariff or a dual 'nightsaver' tariff. As customers on the nightsaver tariff comprise only c.11.4% of all residential ESB customers, it is assumed that all households are on the standard tariff (CER, 2012).

for Energy Regulation (CER) and delineated amongst each consumer category according to the percentage of individual peak (CER, 2009). For the 2009/2010 operating period, domestic customers comprised 43% of total individual peaks, and thus 43% of total renewable subsidies were apportioned to this group (CER, 2009). This proportion appears to be consistent, as domestic consumption comprised 41% of the 2013/2014 calculation (CER, 2013), 44% of the 2011/2012 calculation (CER, 2011a), 43% of the 2010/2011 calculation (CER, 2010a); and 41% of the 2008/2009 calculation (CER, 2008). Thus, household-level charges are calculated by apportioning 43% of the total wind subsidy requirement quoted in table 1 amongst the 2,029,956 domestic customers quoted by CER (2009) in their calculations. This calculates PSO incidence according to the current fixed charge per household. Alternate PSO tariff designs are analysed by calculating the total revenue raised from the HBS sample according to this charge and ensuring that alternate tariff structures are designed such that the same amount of total revenue is raised under each.

Electricity cost savings for domestic consumers will differ depending on whether the actual population or the HBS sample population is used to disaggregate aggregate savings according to each unit consumed. This is due to differences between the sampled and actual population. In order to ensure consistency within the HBS sample, the HBS population is used to disaggregate savings. In order for internal consistency within the sample, The sum total of household-level PSO cost for the HBS population, calculated using the methodology above, is taken as equal to the sum total of per-unit electricity cost savings for the HBS population. This is then apportioned equally amongst all electricity units consumed by the HBS population. The total per-unit savings accruing to the HBS population are shown in Table 2.

Table 2: Electricity Saving due to Wind

Parameter	Value
Total REFIT Cost - HBS population	€1,196.259
Total Electricity consumed	583009.13 kWh
Electricity Saving per kWh	€.00205187

Note: Figures based on HBS population

3.2 Methods of Delineating PSO Cost

3.2.1 Pricing Structures

Savings in electricity cost are distributed according to usage. However, PSO costs are distributed according to the levy design implemented. The following PSO levy structures are considered in this paper.

First, we analyse the fixed standard payment currently in place. The second tariff considered is a linear per-unit payment, where total PSO cost is determined by the number of units consumed. An Incremental Block Pricing (IBP) scheme is the third design analysed. An IBP scheme presents consumers with a per-unit schedule of prices grouped into 3 'blocks' . The first price is applicable to units consumed until threshold 1; the second price for units consumed after threshold 1 but before threshold 2; and the third price for all units in excess of threshold 2. The thresholds of usage at which prices change have been chosen to correspond with the 25th and 75th quantiles of usage for the HBS sample. The first price thus changes to the second price after 51 units have been consumed, whilst the third price applies for all units in excess of 128. The IBP system is structured such that the third price block is 3 times that of the initial block, with the second price chosen such that the sum of PSO revenue is equal to that for the fixed and per-unit levy designs. Thus, Price 1 is 0.0014217/kWh, price 2 is 0.0018/kWh and price 3 is 0.0042651/kWh

the final pricing structure is a hybrid design, where a flat-rate is charged alongside a per-unit rate. Such a structure may be preferred in order to retain the certainty of remuneration associated with a flat-rate whilst also retaining elements of progressivity associated with a per-unit charge.

3.2.2 Social Transfer

The distributional impact of social transfers such as the Household Benefits Package (HBP) will be assessed. We focus on the distributional impact of the Budget 2013 (Department of Social Protection, 2013) changes to the HBP from a unit + PSO charge to a monetary-based charge. An alternative social transfer based on equivalised income is also considered.

4 Factors influencing cost incidence

This section will outline some descriptive statistics that may aid interpretation of the patterns of PSO cost incidence. Figures 1 and 2 graph electricity usage and household size by income decile. One can see that decile 1 and deciles 5-7 are characterised by high levels of electricity usage and a high proportion of large households, suggesting a positive correlation between household size and electricity usage. This corresponds to the findings of Leahy and Lyons (2010) who cite such an effect. The impact this may have on PSO incidence is explored in Figure 3. Figure 3 graphs PSO incidence by household size using a flat rate and fixed per-unit PSO charge. Incidence is determined by income alone for a flat charge. Figures 3 shows that incidence rises slightly with increasing household size for a flat charge, possibly due to higher proportion of large households represented by individuals associated with lower incomes, such as students, unemployed and those engaged in home duties (see Table 3). A stronger correlation is evident for the fixed per-unit charge. As larger households tend to use more electricity, the addition of this effect this may be driving the stronger positive relationship between incidence and household size observed in Figure 3. Conversely, these factors result in a per-unit levy alleviating incidence amongst small households, many of whom may be retired (see Table 3).

Figure 1: Median Income and Electricity Use

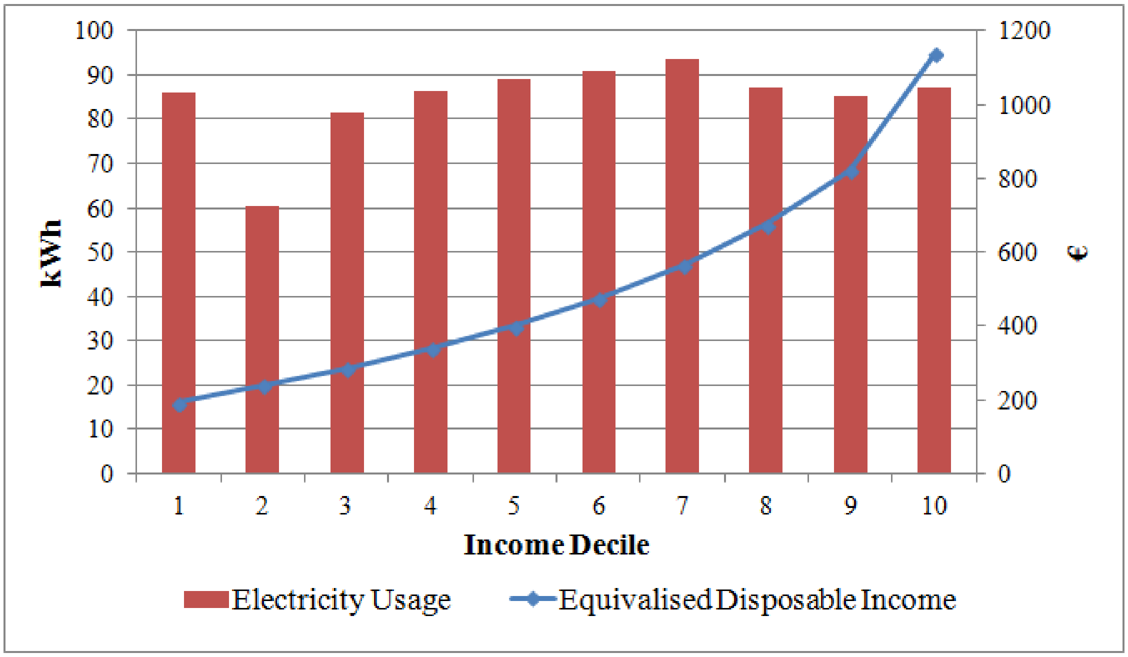


Figure 2: Distribution of Household Size

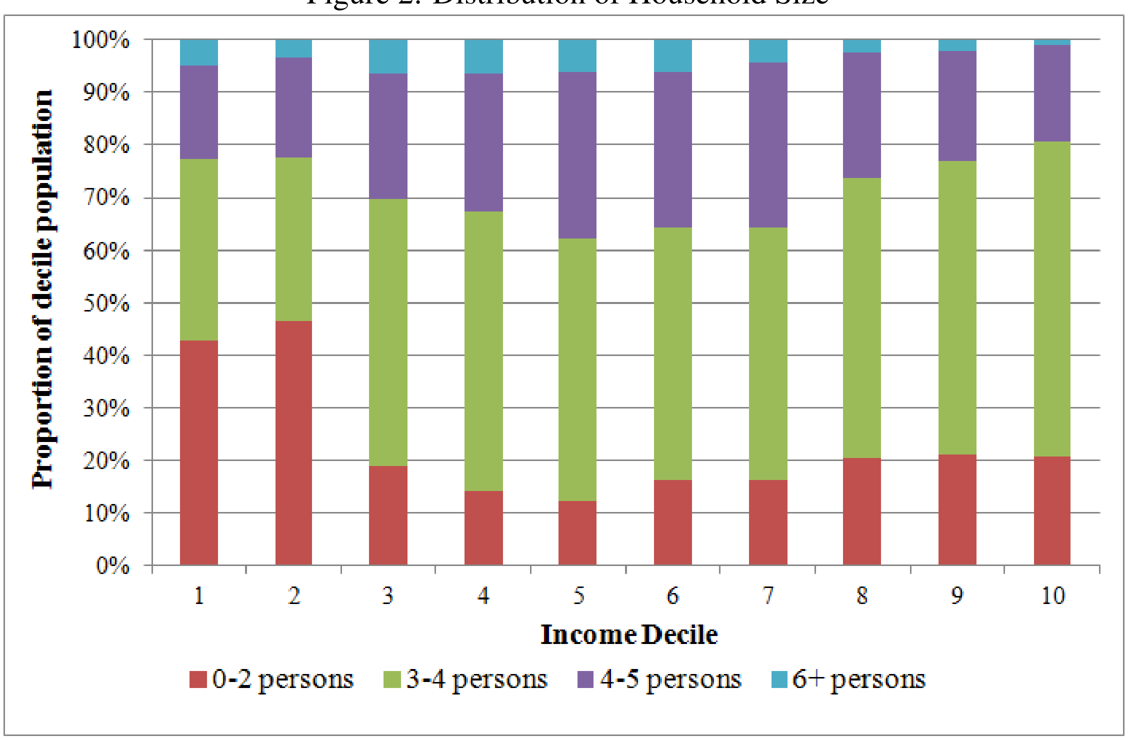
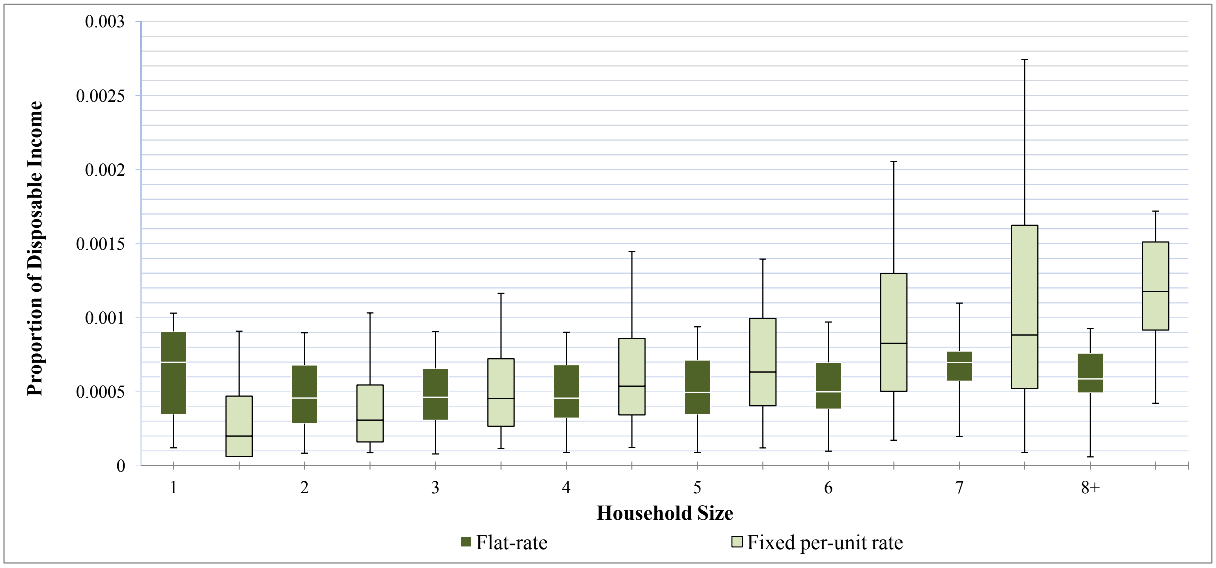


Figure 3: Distribution of Incidence by Household Size



Note: Incidence is calculated relative to equivalised disposable income. Boxplots display incidence at 10th, 25th, 50th, and 90th deciles.

Table 3: Socioeconomic characteristics by household size

	1	2	3	4	5	6	7	8+
Full-time	33.8%	45.2%	50.9%	60.0%	59.1%	57.3%	40.9%	36.7%
Part-time	8.3%	11.7%	14.0%	12.5%	12.3%	15.7%	11.4%	6.7%
Unemployed	13.0%	8.5%	13.9%	13.6%	13.6%	9.6%	15.9%	23.3%
Retired	28.8%	21.8%	5.7%	1.8%	1.4%	1.1%	0.0%	3.3%
Student	3.0%	3.1%	2.6%	1.5%	1.6%	1.7%	0.0%	6.7%
Home duties	5.8%	7.0%	9.9%	9.2%	10.7%	12.4%	27.3%	20.0%
Permanent Incapacity	7.2%	2.6%	2.7%	0.9%	1.0%	2.2%	4.5%	3.3%
Other	0.4%	0.7%	0.9%	1.0%	0.2%	0.0%	0.0%	0.0%

Note: ‘Other’ comprises carers, those not yet at work and the ‘other’ category of the HBS.

Table 4 summarises a number of socioeconomic characteristics by income decile. Focussing on the first decile, there is a higher than average proportion of unemployed, students and retired individuals. Decile 2 is characterised by a large proportion of retired, unemployed, non-manual/manual/semi-skilled workers.

Table 4: Socioeconomic characteristics by decile

	1	2	3 -6	7- 10
SEG				
Professional	14%	10%	22%	58%
Non-manual	14%	22%	25%	20%
Manual skilled and semi-skilled	13%	20%	22%	11%
Unskilled and agri workers	8%	12%	12%	6%
Own account workers and farmers	13%	8%	9%	4%
Other employed and unknown	39%	28%	10%	1%
Employment Status				
Full-time	12%	9%	36%	74%
Part-time	7%	8%	16%	7%
Unemployed	32%	23%	14%	1%
Retired	11%	31%	17%	8%
Student	10%	4%	2%	0%
other/educ/other	28%	25%	14%	3%

Note: average values shown for deciles 3-6 and 7-10. ‘Other’ comprises carers, those not yet at work, those employed in home duties, permanently incapacitated and the ‘other’ category of the HBS.

5 Results I: Distributional Incidence of Cost

5.1 Flat-rate vs Per-unit levy

Incidence by income group is measured according to three metrics; the sum of cost per decile ($\sum_{hh} cost_{hh}$); the sum of each household's proportional cost for each decile ($\sum_{hh} \frac{cost_{hh}}{income_{hh}}$) or household-level proportional cost measured at different intervals along the income distribution. Ceteris paribus, the relative distribution of incidence outlined in this section will remain constant, with aggregate results changing according to the trends outlined in the literature of Section 2.

First, the incidence of the current flat rate structure will be compared to that of a fixed per-unit tariff structure. Figure 4 shows the absolute incidence per income decile. The imposition of a per-unit PSO charge has a marginal effect on absolute incidence. Deciles 5-7 have the greatest increase, as these households use the most electricity (see Figure 1) which is in turn driven by a high proportion of large households. The first decile has a marginal increase in overall cost, also likely to be driven by the proportion of large households present. Decile 2, and to a lesser extent decile 3, shows a considerable decrease in incidence, primarily due to the prevalence of retired persons who tend to use less electricity.

Figure 4: Gross cost by income decile

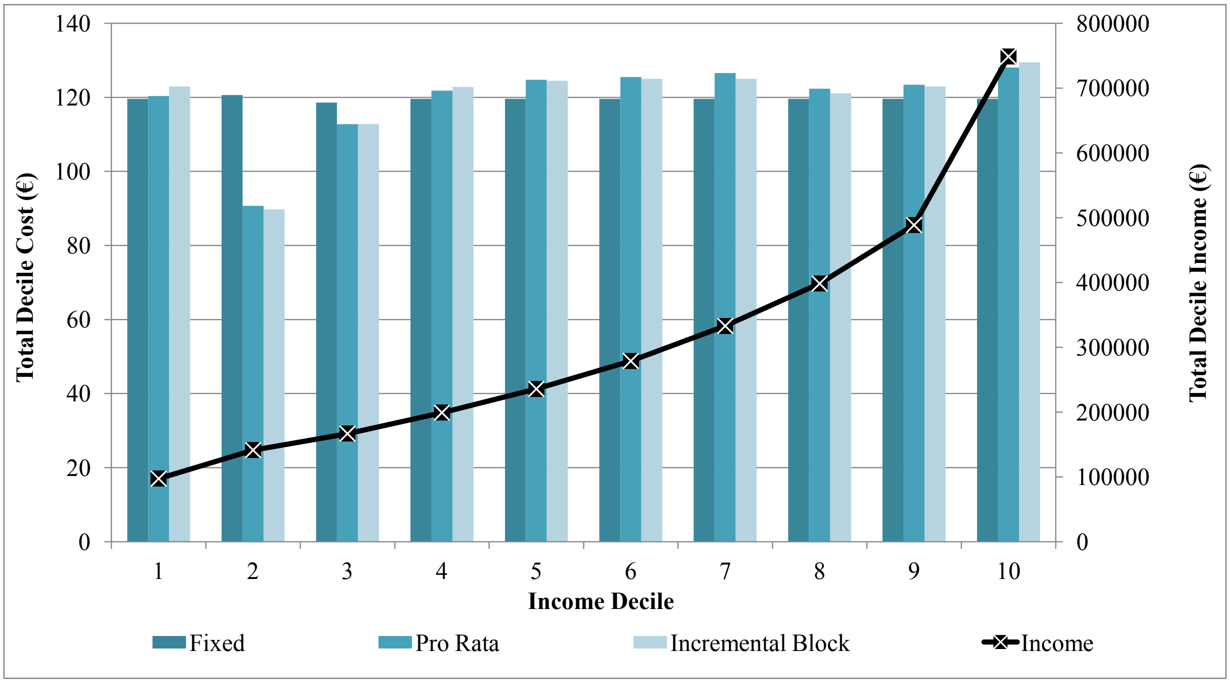
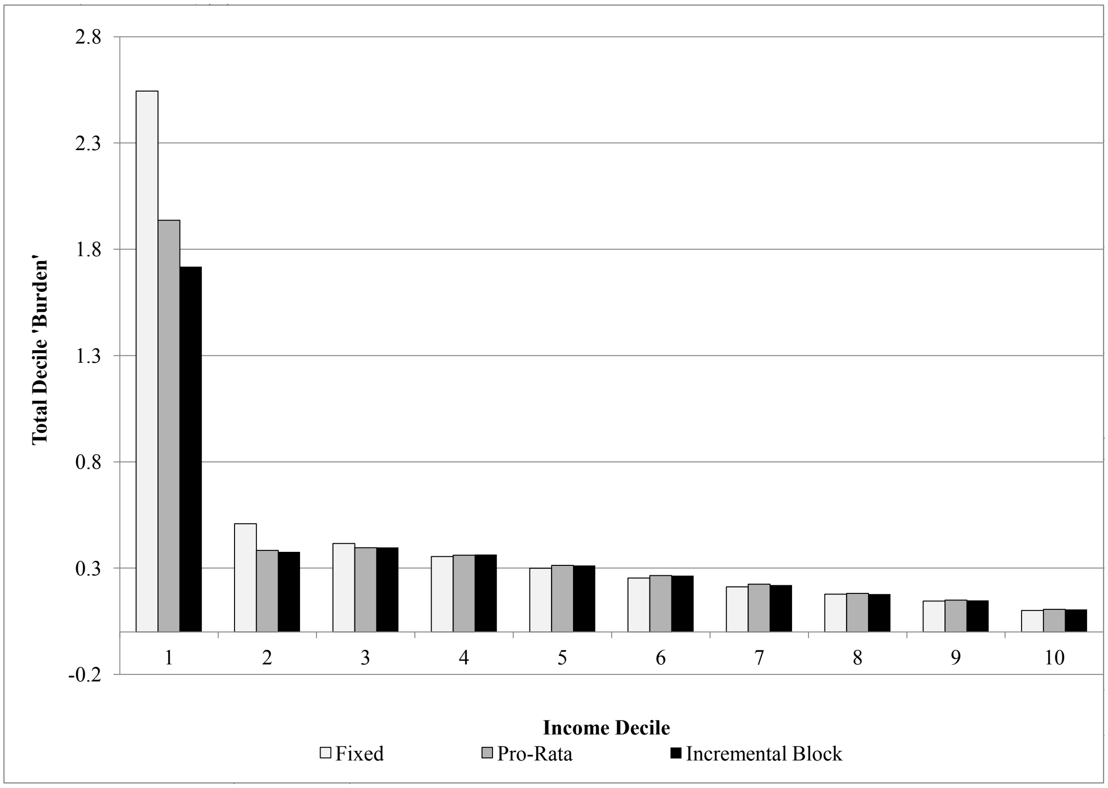


Figure 5 shows that the ‘burden’, or impact relative to income, increases by 5% for deciles 5-7, and decile 10 with the introduction of a per-unit levy. Deciles, 4,8 and 9 have an increase of about 2-3%. The proportional burden falls by 23% and 24% for deciles 1 and 2 respectively. Despite these changes, total decile burden for decile 1 is still 7 times greater than the average rate for deciles 4-10. Deciles 2 and 3 benefit from a per-unit levy to the extent that the burden for these deciles is brought to a similar magnitude to that of decile 4.

The within-decile distribution of income and electricity usage is a considerable factor in driving overall income group findings. Figure 6 shows that there is a wide distribution of incidence amongst households within each decile. For the flat rate levy, this distribution is driven by the distribution of household income alone, whilst variations in income and electricity usage drive incidence for a fixed per-unit charge. This results in a wider distribution of incidence for the fixed per-unit charge. Focussing on the first decile, we see that median values for both tariff designs are approximately the same. The distribution of incidence for the flat rate tariff increases to a greater extent than it decreases, driven by households with high decile incomes in the tail of the decile distribution. This is in contrast to the fixed per-unit tariff, where incidence has an equally large positive and negative deviation, with this change in incidence due to the variance of within-decile electricity usage. This large variance may be explained upon closer inspection of the population

Figure 5: 'Burden' by income decile



of this decile. Income and electricity use in decile 1 has a correlation coefficient of -0.122, in contrast to the weakly positive correlation of 0.062 for the population as a whole. The median equivalised disposable income for those who benefit (€196) is greater than for those who lose out (€176.4), whilst median electricity usage amongst winners is lower (51.4 units vs 135.9 units). This intra-decile variation is counterintuitive, as evidence to date suggests a positive correlation between use and income (Leahy and Lyons, 2010). For decile 1, table 5 gives a breakdown of electricity use and income by socio-economic group to aid understanding of this finding. This illustrates that households headed by retired, unemployed and 'other' employment statuses contain a majority of beneficiaries. Table 5 also shows that these groups use less electricity than alternate groups, as evidence to date predicts. However, one can see that median income levels are higher than those employed or students, socioeconomic groups associated with higher levels of electricity use (Leahy and Lyons, 2010). As such, households who lose out from this change are those who are employed but have very low equivalised incomes. As 77% of beneficiaries in decile 1 have fewer than 3 inhabitants, those who lose out are likely to be larger households of 3 or more. This low rate of employed beneficiaries is also evident amongst decile 3, but rises to the range of 50-60% for all other deciles. In summary, this finding suggests that those who are worst affected are large households containing either students or an employed household head with very low household income.

Table 5: Breakdown of incidence for Decile 1

	% Beneficiaries	Electricity (kWh)	Income (€)
Full-time	42.9%	115.9645	163.2033
Part-time	43.2%	108.695	181.3467
Unemployed	58.3%	85.23404	196
Retired	77.4%	49.8227	188
Student	41.0%	108.695	143.4
Other	63.6%	72.18439	200.3231

'Other' comprises carers, those not yet at work, those employed in home duties, permanently incapacitated and the 'other' category of the HBS

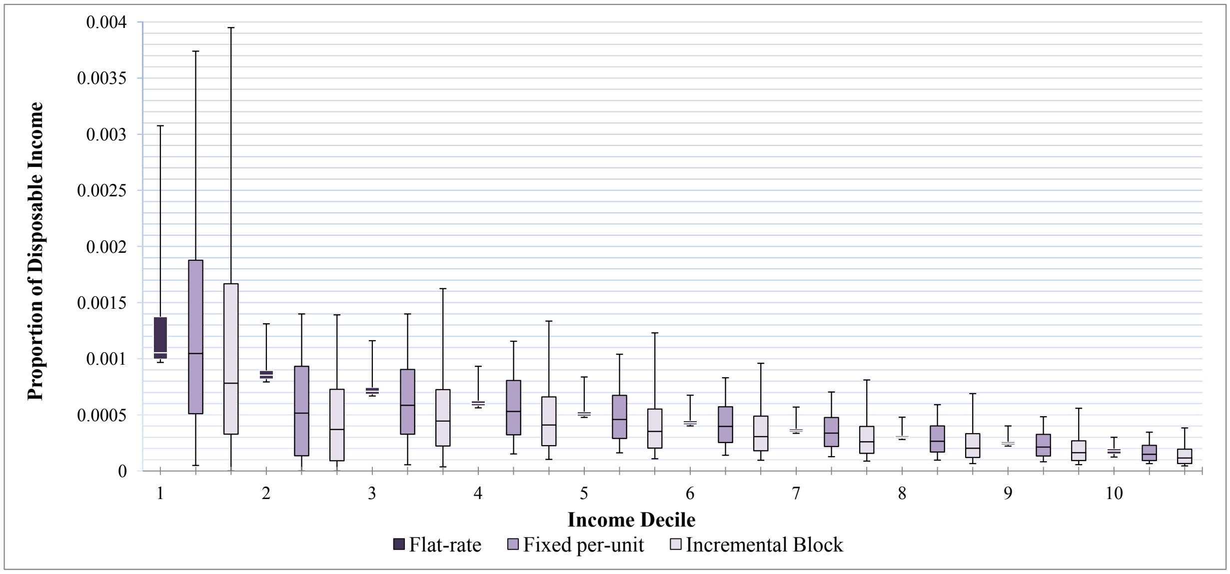
To give insight into the magnitude of change faced by 'winners' vs 'losers' in decile 1, median PSO cost rises to €0.34 (standard deviation of 0.177) for households that lose out and falling to €0.097 (standard deviation of 0.0627) for households that benefit. 57% of individuals in this decile benefit with a lower degree of variability. This results in the magnitude of benefit being greater than the magnitude of loss, resulting in the overall burden for this decile to fall. Analysing the remaining deciles, median values of incidence for the per-unit levy are considerably lower for deciles 2-5. However, the variance is much higher. Although this is sufficient for overall incidence to fall for deciles 2-3, total population incidence for deciles 4-5 remains stagnant or increases marginally. Overall, we see that moving to a per-unit levy results in a considerable reduction in the proportional burden for lower income groups, whilst marginally increasing the proportional burden for higher income groups. Proportional incidence rises marginally for deciles 6, 7 and 9, whilst remaining stagnant for deciles 8 and 10. Overall, 59% of households across all deciles benefit from this change.

5.2 Non-Linear Structure: Incremental Block Pricing

Non-linear structures result in a per unit incidence that is less than a linear structure for initial units consumed, with a greater per-unit charge for subsequent units. As such, households with low usage incur a lower PSO charge than under a linear increment. In general, higher income is associated with a greater rate of electricity usage (Leahy and Lyons, 2010), and thus one would expect such a measure to reduce regressivity of incidence across the entire income spectrum. Given the imperfect correlation of income and electricity use discussed in Section 5.1 the within-decile distribution of this effect may be subject to uncertainty.

Figure 4 shows that a greater overall cost occurs for the first, fourth and tenth deciles, as there is a larger proportion of heavy users in these deciles. Of greater importance is the impact

Figure 6: Distribution of Incidence by Income Decile



on decile burden and the distribution of income change. Relative to a fixed per-unit levy, first decile proportional incidence falls by 12.7% for an IBP tariff. Proportional incidence is of similar magnitude for all subsequent deciles. This is due to the rising income levels resulting in proportional incidence being less sensitive to change.

Although total decile burden has fallen for these non-linear pricing structures, the pattern of within-decile inequality has changed. Figure 6 compares the distribution of incidence for the IBP tariff with other tariff strructures. Each levy structure has a similar degree of variance and thus the within-decile distribution of incidence is of a similar magnitude to that outlined for the fixed per-unit levy of Section 5.1, however there is a lower range for an IBP tariff. This suggests that, overall, an IBP tariff is effective in reducing the incidence for the majority of consumers, with 71% of all households benefitting. This is achieved by shifting the burden of cost to heavy users which results in the the usage threshold at which the net impact turns into a cost rises from 98.97kWh to 124.29kWh.

Heavy users to which this burden is shifted are most predominantly located in the first, fourth and tenth deciles. This is reflected in figure 6, where these deciles have a lower interquartile range but extended tails. Focussing on decile 1, median electricity consumption for those who lose out is much greater than for than those who benefit (200.05 vs. 60.80), whilst median incomes are slightly lower also (€154.67 vs. €169.21). This is considerably greater than the difference observed for the fixed per-unit tariff of section 5.1. This results in a greater median PSO cost of €0.519 (standard deviation of 0.39) for households that lose out and falling to €0.093 (standard deviation of 0.062) for households that benefit.

The findings of this and the preceding section have shown that per-unit levies reduce regressivity over the entire income spectrum. Non-linear structures may lead to a greater overall reduction in regressivity, however, the imperfect correlation of electricity usage with income results in a higher incidence amongst high users. The next section will analyse levy structures that may retain elements of the reduced regressivity found in this section whilst attempting to alleviate the high proportional incidence amongst low income groups with high electricity usage.

5.3 Hybrid flat-rate and unit-based combinations

A hybrid combination of a unit-based and fixed tariff structure is first considered as a comprimise to retain the progressive nature of a per-unit based structure whilst alleviating the increased proportional PSO incidence amongst low income groups of the first decile. Figure 7 shows that hybrid designs have a similar level of incidence for deciles 4-10 than both fixed and flat-rate levies. Hybrid structures are less regressive than a flat rate structure and more regressive than a fixed per-unit structure for deciles 1-3. For the first decile, total incidence is 11% and 16% less than the flat rate tariff for fixed and IBP-based hybrid tariffs respectively. However, these tariffs are respectively 15% and 9% more burdensome on this first income decile than the fixed per-unit tariff. Figure 8 shows the distribution of incidence for these hybrid structures. Results indicate that for most income groups, median incidence for both hybrid designs is as regressive or more regressive than a fixed per-unit levy. A hybrid design works to reduce the variability of incidence, however, with a narrower interquartile range observed across all deciles. This reduced interquartile range is greater for an IBP levy structure, but occurs at the expense of a higher upper tail due to the high cost such a levy design imposes on heavy electricity users.

Once again, the intra-decile implications of these effects are analysed for the first income group. The addition of a flat charge to a fixed per-unit levy results in an increase in median incidence by10% Median incidence of an IBP tariff is approximately the same as a fixed per-unit tarff. A less dispersed distribution of proportional incidence is observed for this first decile under both hybrid regimes (Figure 8).

Concentrating on the first decile, it is found that a hybrid regime is effective in reducing the negative impact on high electricity users, however these are in the minority. 27.8% of households in the first decile benefit from this change, with usage ranging from 124-697 kWh. The 72.15% that lose out have a usage range of 0-123kWh. Relative to a per-unit regime alone, this measure appears to benefit individuals in the first decile who tend to have a lower equivalised disposable income, as the average income of those who lose out is €169.20 whilst income is €154.67 for those who benefit. Although there are more losers than winners when it comes to introducing a hybrid regime, the expected magnitude of a loss (mean€0.054; sd: €0.0308286) is much less than the expected magnitude for a gain (mean€0.158; sd: €0.198). However, as Figure 7 shows, the increase in burden outweighs the reduction in burden and results in a net increase in burden for decile 1.

Figure 7: Incidence by Income Decile

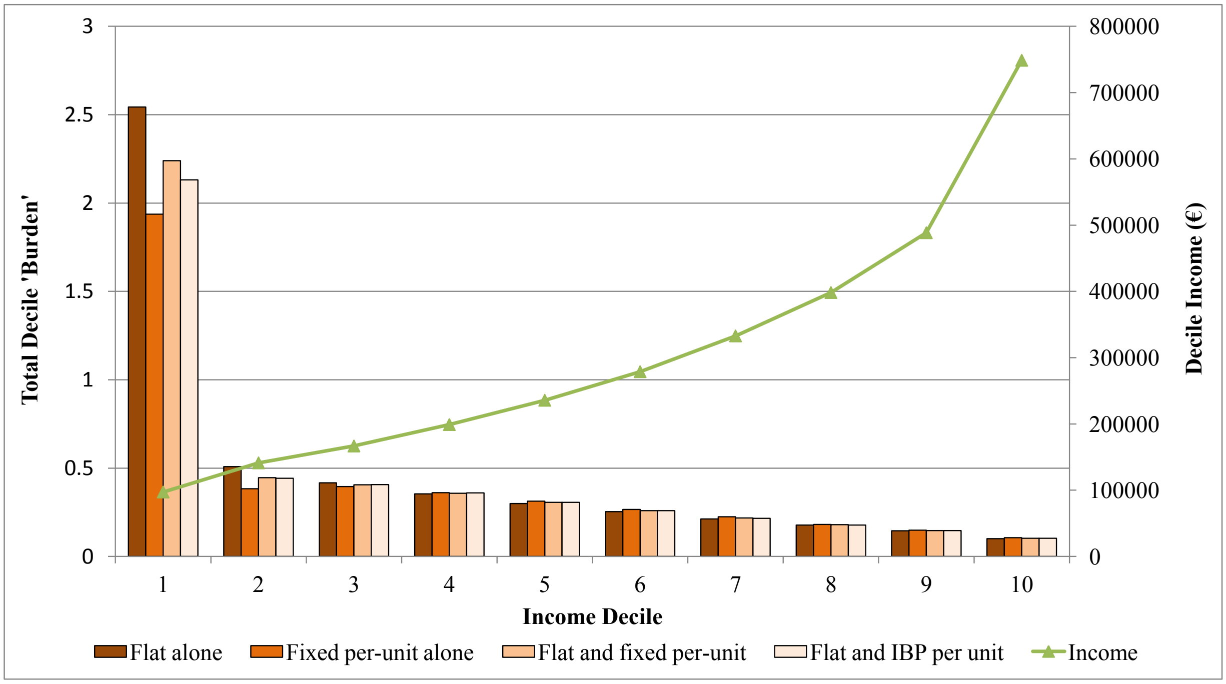
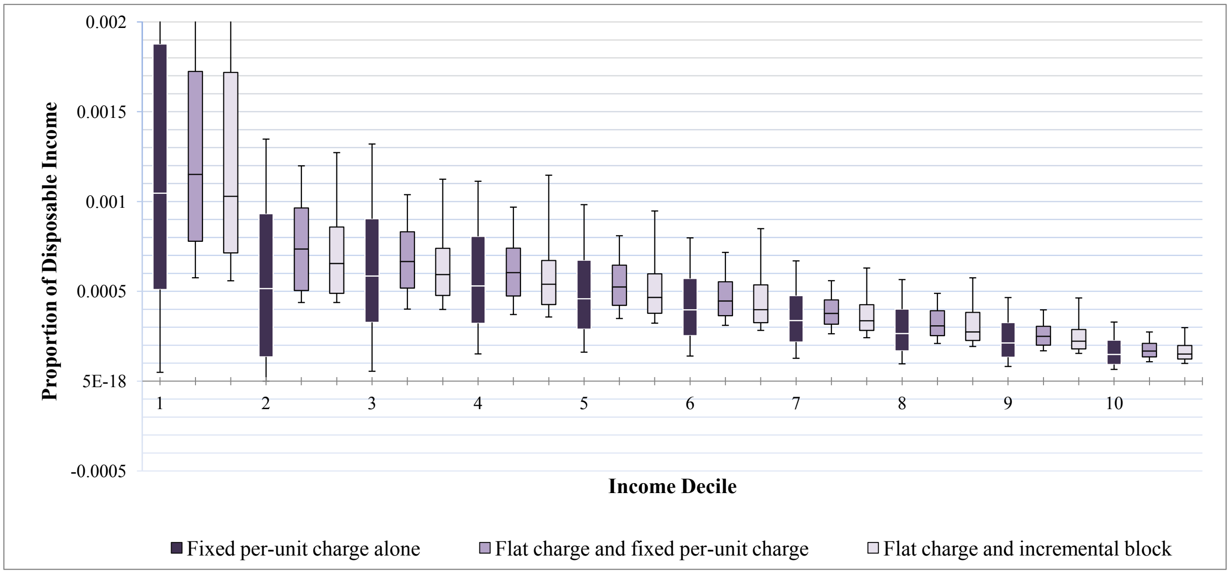


Figure 8: Distribution of Incidence by Income Decile



6 Impact of financing PSO by social transfer

This section analyses the impact of social transfers may have on PSO incidence. In particular, this section analyses the implications of financing PSO costs for poorer households as part of Ireland's free electricity allowance scheme, a component of the household benefits package (HBP). In doing so, this provides an ex-post analysis of the distributional impact of changes in the HBP as part of Budget 2013. When interpreting these findings, one should note that the HBP is financed through the tax-benefit system. The distributional incidence of such costs are difficult to identify, as taxes are sourced from a variety of entities (e.g. households, firms, industry) and through a number of channels (e.g. VAT, income tax, corporation tax, etc.). Instead of inaccurately approximating the distribution of this cost, the total cost to the taxpayer is quoted as a benchmark of the macroeconomic cost of redistribution against which the potential benefits may be gauged.

Two social transfer mechanisms are considered; the pre-Budget 2013 mechanism whereby those eligible for the household benefits package do not incur the PSO cost alongside a simple weekly equivalised income threshold of €238[4]. This value is equal to the median income for those in the second decile whilst the cost of subsidy to this point approximates the cost of HBP subsidy according to simulations using HBS data.

Overall, 16% of all households avail of the free electricity allowance as part of the HBP. One

[4]It should be noted that this is equivalised income, where disposable income is adjusted according to the number of inhabitants in a household using an equivalence scale

can see that subsidisation via the HBP is effective in reducing the burden amongst the first decile by 37.9%, but this is still 4.75 times greater than the pre-HBP average for deciles 2-10, and 6.27 times greater than the post-HBP average for this cohort. This is due to the fact that only 20.24% and 40.37% of households in the first and second deciles are HBP recipients. This results in the distributional result of Figure 10 where this benefit is distributed amongst a subset of individuals which shifts the distribution downwards, but the majority of individuals in decile 1 still must bear a proportional burden greatly in excess of individuals in all other deciles. Furthermore, not only is redistribution through the existing HBP ineffective in targetting those most affected in the first decile, 62.4% of HBP recipients are in deciles 3-10, beneficiaries who have a PSO and electricity cost which is of a much lower proportional burden. Indeed, the distribution of beneficiaries is non-trivial for deciles 5 and 6, where a zero cost at the 10th percentile is observed for both deciles.

Potential reasons for this suboptimal targetting may be identified upon closer inspection. Overall, 57.9% of recipients are retired, whilst those involved in home duties, permanently incapacitated, not yet at work or not available for work for 'other' reasons comprise 25.8% of all recipients. Focussing on decile 1, full-time and part-time employees are only 5.1% of recipients, whilst students comprise only 1.7% of recipients. 32% of decile 1 households are unemployed but only 8% of this population avail of the free electricity allowance. These trends suggest that many of the groups identified as being negatively affected by a regressive PSO are not beneficiaries of the free electricity allowance.

Assuming all individuals apply, one can see that an alternative equivalised income-based measure corrects these problems. The alternate HBP allowance reduces the burden completely for decile 1, whilst reducing the burden for decile 2 by 56%, relative to pre-HBP incidence. To faciliate this, there are no beneficiaries amongst deciles 3-10, with total gross cost for these deciles growing by 14%. Relative to the distribution visa the current HBP, Deciles 3, 4, and 5 face a greater burden of 40%, 24% and 19% respectively. It should be noted that this section is carried out relative to a flat-rate charge. Assuming no behavioural response, this may be interpreted as an upper bound on potential costs relative to unit-based schemes. This is because electricity use is low for decile 2 and the high usage for deciles 5-7 cancels out the high usage for decile 1 to result in a lower net cost subsidy. The magnitude of incidence for decile 2 will fall proportional to the change illustrated in section 5, with a similar proportional increase for deciles 3-10.

In order to achieve these distributional benefits, this subsidy must be financed by the taxpayer. Using the weighted population of the HBS, it is estimated that relative to the flat-rate PSO levy, the HBP-based subsidy costs in the region of €53,979 per week, whilst the alternate equivalised income-based subsidy costs €53,694.

Figure 9: Total Burden: Post-HBP

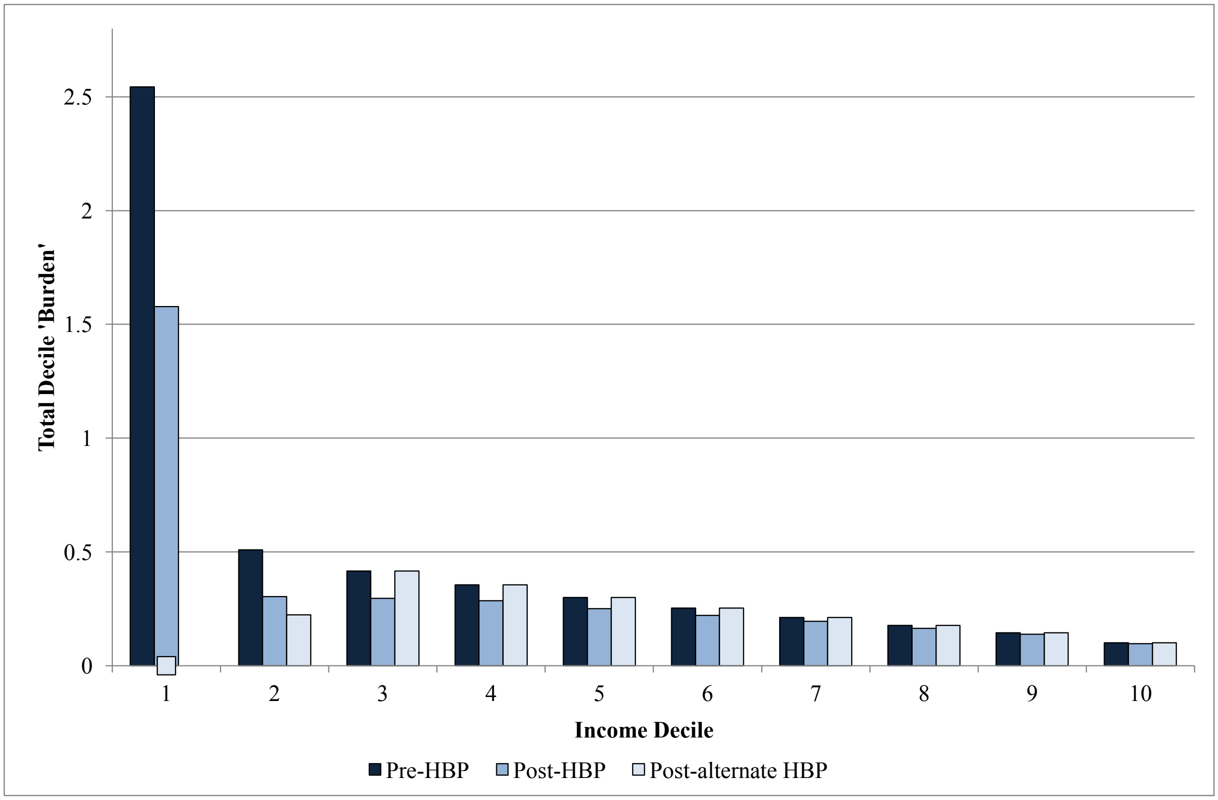
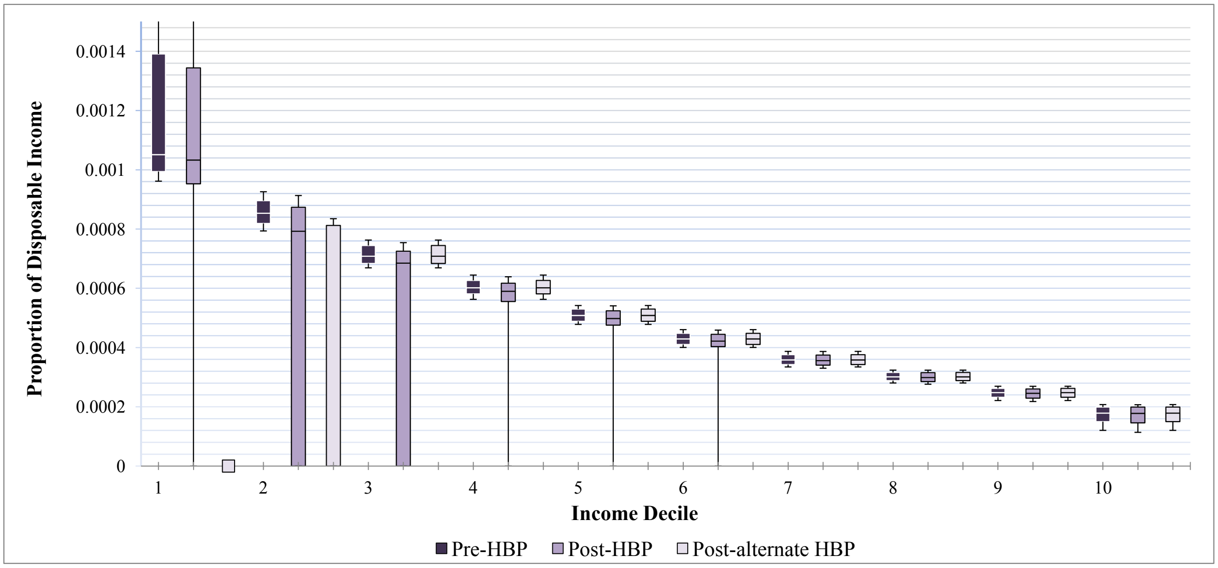


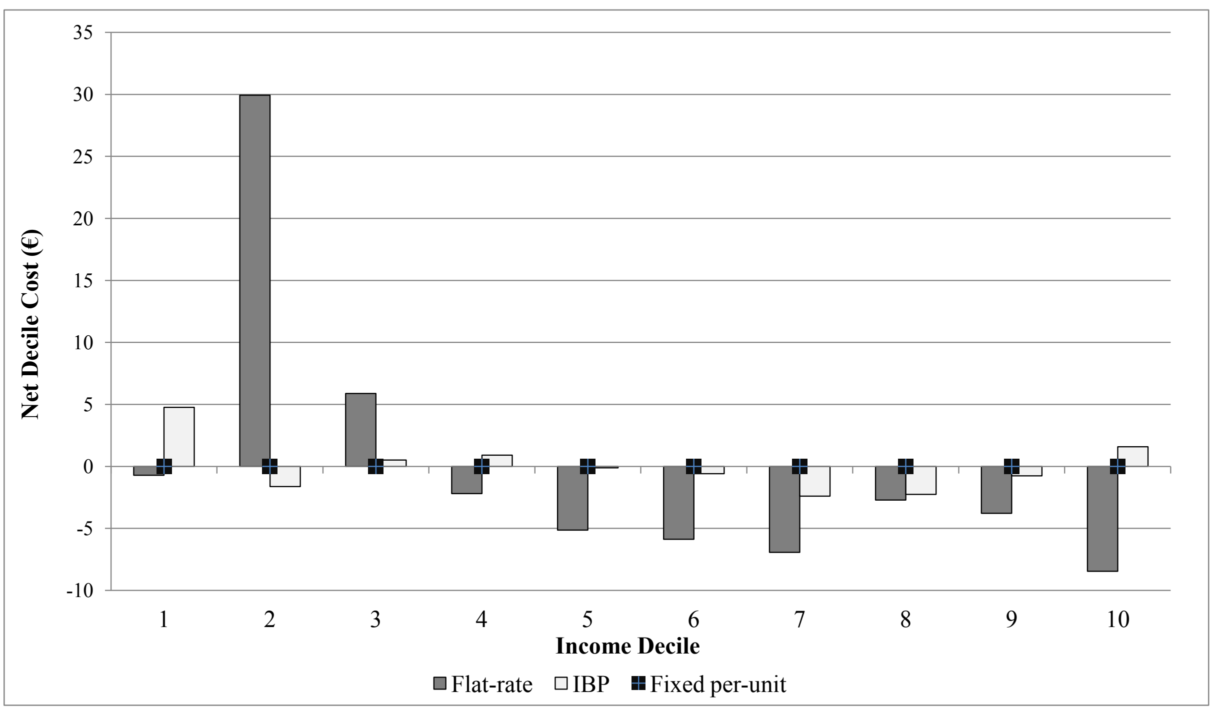
Figure 10: Distribution of Incidence: Post-HBP



7 Net incidence of PSO cost increase and electricity price reduction

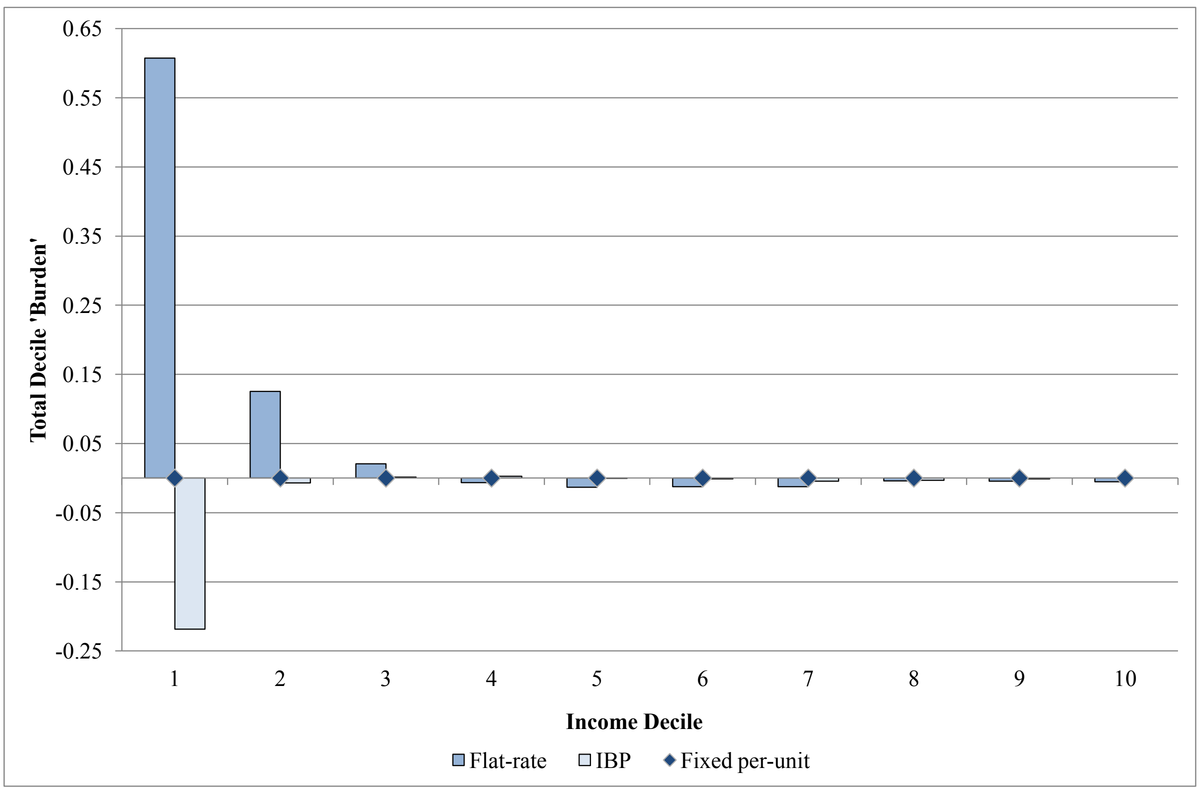
Having analysed the distribution of cost, the final contribution of this paper is to assess the impact of this cost net of electricity usage. The total net cost by decile is displayed in figure 11. One can see that the flat tariff is somewhat regressive, with deciles 4-10 incurring a net benefit whilst deciles 2-3 incur considerable cost. Decile 1 incurs a small net benefit due to the number of high users in this cohort. A fixed per-unit tariff results in a net cost of zero for all income groups as cost is directly cancelled out by a per-unit levy. An IBP tariff structure transfers the incidence to heavy users, reducing the net impact on deciles 2-3, however the presence of heavy users in decile 1 gives a considerable net cost for this decile. Interestingly, an IBP levy results in a negative net cost for deciles 5-7, deciles characterised by high aggregate levels of use. This is due to the distribution amongst households, with high use driven by higher rates of use amongst most households, as opposed to extremely high use by a subset, a characteristic evident in decile 1.

Figure 11: Total Net Cost by Income Decile



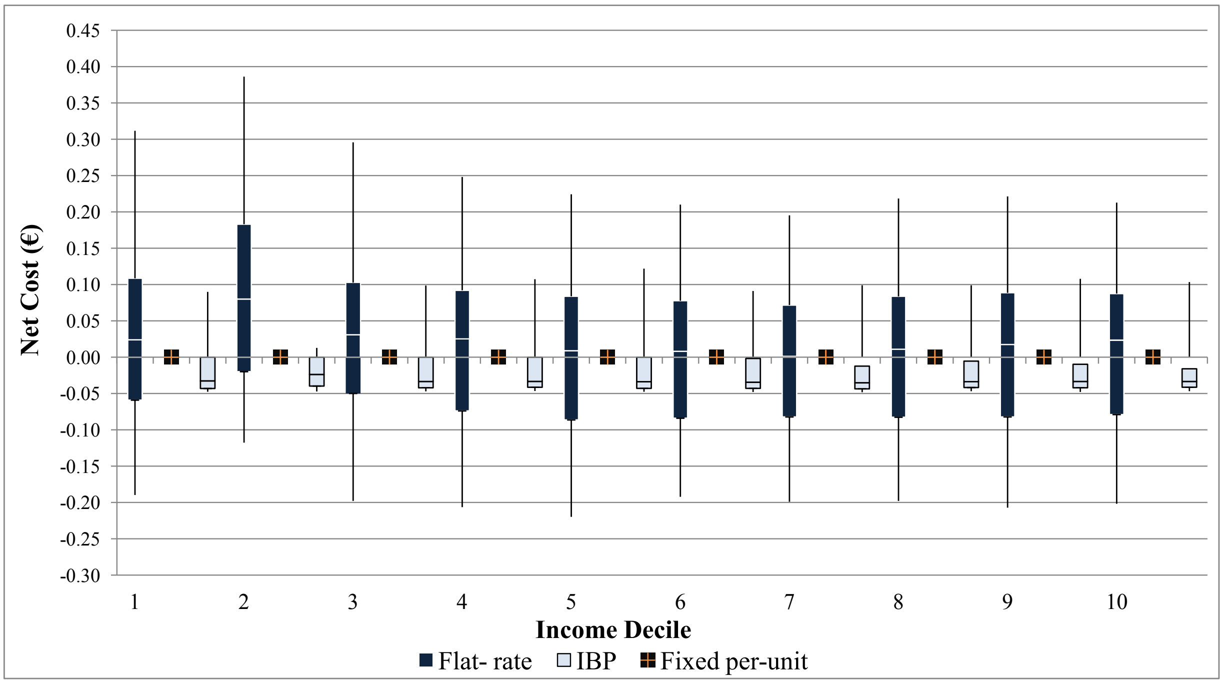
The proportional burden is analysed in Figure 12. One can see that for 4-10 that net impact and thus changes in tariff structure has a negligable impact on burden. The flat rate charge, despite resulting in a net negative cost, is a great proportional burden on the first income decile. In absolute terms, the magnitude of gain is greater than the magnitude of loss and thus net absolute cost shows a reduction. However, this gain is distributed amongst fewer households. When one considers that a greater number of households lose out, as Section 5 has discussed, summing each household's change in net proportional incidence results in an increase in proportional burden. An IBP tariff shifts incidence to heavy users. This results in a net increase in aggregate cost for decile 1 as a disproportionate amount of high users exists, but a reduction in household proportional burden as this increase is concentrated on fewer households and the negative proportional cost for the greater number of households outweighs the additional burden on the minority.

Figure 12: Incidence by Income Decile



To understand the distribution of absolute cost by decile, Figures 13 shows boxplot distributions of net absolute cost for each decile. One can see that the flat rate tariff shows that greater net cost is placed on households in deciles 1-4, whilst deciles 5-7 have a lower distribution of incidence due to their greater usage. Considering the trend of income for each decile, this results in the degree of regressivity displayed in figure 12. The fixed per-unit structure addresses this by offering a neutral net impact across all deciles. In the other extreme, one can see that an IBP tariff results in a net benefit for the majority of households across all income deciles, with the balance of cost being borne by large households. Given that incomes for lower deciles are lower, this saving is of greater benefit for low income households. This finding would suggest that such non-linear tariff structures benefit the majority of the population whilst also disincentivising heavy use, but it should be noted that behavioural response is not taken into account.

Figure 13: Distribution of Net Absolute Incidence



8 Conclusion

Research to date has demonstrated that the aggregate cost of renewable subsidy in Ireland is cancelled out by reductions in the wholesale cost of electricity (Clifford and Clancy, 2011). However, the incidence of PSO levies imposed to finance renewables subsidy in Ireland differs from the potential incidence of cost savings. Given this difference, it is important to understand the incidence current and potential future policies may have on household welfare. This is of increasing importance as renewable subsidy comprises a greater proportion of total electricity cost, a trend outlined by Devitt and Malaguzzi Valeri (2011) and Clifford et al. (2013). It has thus been the purpose of this paper to analyse the incidence impact PSO levy design may have on domestic electricity consumers in Ireland.

Unlike analyses in the literature to date, this paper has analysed the distribution in terms of total absolute incidence per decile, the sum of each household's proportional incidence and the distribution of proportional incidence per decile. This has given added depth to the understanding of incidence, whereby intra-decile variation has been elicited and the factors driving unusal trends have been identified. The findings of this analysis may be interpreted in both a retrospective and prospective context. In a retrospective context, this paper has provided insight into the distributional incidence of renewables subsidy. This paper has shown that the current flat-rate PSO levy has been regressive in nature. Relative to a per-unit levy, it has imposed a greater burden on the majority of individuals in almost all income deciles, an effect that is considerably greater in the lowest two income deciles.This paper has highlighted that the presence of high electricity users in the first decile results in a greater aggregate burden and distribution of incidence for this decile, relative to a unit-based levy. However, such heavy users are in a minority.

This paper has also analysed the distributional impact of social transfer mechanisms to alleviate PSO burden. The impact of that covering PSO costs through the free electricity allowance of Ireland's Household Benefits Package (HBP) has been analysed, something which Budget 2013 removed from the current benefits package. Given a high proportion of beneficiaries in deciles 1 and 2, these deciles are the greatest potential beneficiaries of such a social transfer. However, beneficiaries exist throughout all deciles. Although a considerable number of beneficiaries exist in income deciles 3-10, the reduction in 'burden' is much less as the income for this cohort is higher. This cost has also been considered net of wholesale price reductions and the distribution of incidence assessed.

In a prospective context, this paper has analysed the distribution of cost incidence for alternate per-unit-based policies, whilst the impact changing Ireland's free electricity allowance for low income households has also been assessed. It has been found that per-unit based policies are less regressive than the flat-rate charges currently in place. The total burden for low income deciles falls for a fixed per-unit charge and falls further for an IBP-based charge. These policies, however, shift the burden to high electricity users in these deciles, thus having a regressive impact on a subset of the population. Hybrid unit and flat-rate based policy structures are considered to alleviate this problem but are found to be inferior to social transfer mechanisms. Indeed, it is demonstrated that the HBP-based transfer mechanism is sub-optimal, with an equivalised disposable income-based measure found to be considerably more effective.

This paper will provide the basis of a number of future extensions. The efficiency costs of PSO levies, which drive a wedge between marginal cost and the cost of consumption, will be the first topic of analysis. Second, this paper has provided descriptive analysis as to potential factors that are correlated with changing incidence. Although providing an intuitive understanding of factors which may contribute to the results outlined, such inferences may not be interpreted as causal. A more in-depth analysis of factors driving such regressivity will be the subject of alternate analysis. Finally, the findings of this paper do not assume a behavioural response to changing tariff structure.

As PSO levy currently comprises a small share of a consumer's electricity budget and so this is assumed to be negligable. Future work will consider the implications such response may have.

The importance of this paper lies in the relative distribution of impacts identified. Such relative impacts remain will constant regardess of the magnitude of the PSO. As renewables deployment in Ireland progresses to meet current 40% targets and unknown levels of deployment beyond that, the magnitude of these effects will increase to represent a greater proportion of both electricity cost and become a more significant determinant of household welfare. Indeed, such issues have become of great concern in alternate jurisdictions where the cost of renewables policy has emerged as a topical policy issue. In a global energy market characterised by increasing proliferation of low-cost gas, the potential cost of renewables deployment is becoming an ever-increasing concern in policy and academic debate. This paper provides a timely contribution by providing an in-depth understanding of the potential implications that current and alternate means of financing renewables subsidy may have on household welfare.

Appendices

A ESB Customer Supply Tariff Structure

Table 6: ESB Customer Supply Tariffs (2009/2010)

Detail		Urban	Rural	Unit
Standard Tariff		0.141	0.141	per kWh
Nightsaver Tariff	day	0.1506	0.1506	per kWh
	night	0.0745	0.0745	per kWh
Urban Standing Charge		0.252	0.336	per day
Rural Standing Charge		0.346	0.438	per day

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