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Abstract

Using household survey data, we investigate the distributional incidence of the A3 surcharge, which recovers the cost of RES-E support in Italy. The surcharge is found to be markedly regressive. The fairness of such a system is questionable as RES-E support is justified by public policy objectives. We thus consider a carbon tax as an alternative means for recovering the cost of RES-E support. The literature suggests that energy is a less necessary good than electricity, typically because motor fuel consumption more closely follows income than electricity consumption does. If so, a carbon tax would be less regressive than the A3. Our findings confirm this. Also, the cost of the carbon tax would be more evenly distributed, because its base is diversified. Furthermore, different economic and climatic conditions mean the A3 and the hypothesized carbon tax impact differently across regions. The impact of the A3 is about twice as big for southern regions compared to northern ones, while the carbon tax would impact similarly across the country. A reform that replaces the A3 with a carbon tax a) has no cost, b) achieves greater equity, and c) involves tax earmarking. These three elements should help making it accepted by the public.

Keywords

RES-E support, Carbon tax, Distributional effects.

1. Introduction

Under the Climate and Energy Package, the EU is committed to binding targets for greenhouse gas emissions and renewable energy.[1] A 20% reduction in emissions, from the 1990 level, and 20% of renewable energy in total energy consumption are the EU's "20-20" targets for 2020. The EU Emission Trading Scheme (EU ETS), which puts a cap on carbon dioxide (CO_2) emissions of the largest energy consuming industries, is the prime instrument for achieving the emission reduction target. At the national level, feed-in tariffs, feed-in premiums, tradable green certificates, tender systems, tax benefits and public funds are used to incentivise renewable energy sources (RES). Following the economic crisis, which took hold in Europe just before the Package came into force, in 2009, the EU ETS and RES support have had so far opposite destinies: while the price of CO_2 in the EU's carbon market progressively tumbled, RES support, especially support to renewable electricity (RES-E), has reached significant levels in many Member States (MSs). [2]

By definition, RES support in the form of tax benefits and public funds weighs on the government budget. However, RES-E support in Europe is principally carried out through feed-in tariffs, green certificates and tender systems, which in the vast majority of MSs are paid by electricity consumers.[3] Specifically, the costs of feed-in tariffs and public tenders are directly recovered through surcharges, while the cost of green certificates is transferred from conventional generators to consumers via the wholesale and retail markets. In either case, making consumers pay is questionable from the standpoint of fairness. Electricity is indeed a necessity good par excellence. Therefore, contributions proportional to consumption are regressive across households; that is, in relative terms, the burden declines with rising income. At the same time, RES support is motivated by public policy objectives, notably environmental protection, technology innovation, energy security and employment. As such, the cost should be covered by the government budget (Chawla and Pollitt [2013]). In that case, assuming that the general tax system reflects society's preference concerning equity, the problem of regressiveness would not arise. Similarly, energy intensive productions would not be penalised any more than others.

There are different reasons, however, for which RES support, in Europe, is largely paid by consumers. First and foremost, the existing constraints on public finances do not leave margins for ambitious new government expenditure programs. Secondly, as not directly dependent on future budgetary decisions, surcharges and green certificates (with a minimum guaranteed price) have the advantage of providing higher investment security (Neuhoff *et al.* [2013]). Moreover, both with surcharges and green certificates, consumer prices are higher (than they would be without) and this promotes energy efficiency (Koutstaal *et al.* [2009]). In view of these considerations, a general shift of the burden from consumers to the government (i.e., from surcharges to taxes) is unlikely, at least in the near future. Still, a system for allocating costs more equitably is much needed.

With reference to Germany's main RES-E support mechanism, Neuhoff *et al.* (2013) note that many industry consumers are exempt from the relative surcharge and that, therefore, the burden could be redistributed by removing at least part of those exemptions. This option, which highlights a trade-

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1 The Climate and Energy Package consists of six legislative texts: a Directive (29/2009) revising the EU ETS; a Decision (406/2009) setting national targets for CO_2 emissions from the non-ETS sector; a Directive (28/2009) setting national targets for RES in the energy mix; a Directive (31/2009) creating a legal framework for carbon capture and storage; a Regulation (443/2009) setting standards for CO_2 emissions from new cars; a Directive (30/2009) revising the Fuel Quality Directive.

2 A useful classification of RES-E support mechanisms is found in EWEA (2012). On the rationale(s) for RES-E support, as a complement to the EU ETS, see Lehman and Gawel (2013). For a discussion of price versus quantity mechanisms, see Menanteau *et al.* (2003).

3 CEER (2012) shows that this is the case for 20 of the 22 MSs therein considered.

off between competitiveness and equity objectives, is being debated in Germany and is valid for other countries too. Given rising electricity prices in Spain, Batlle (2011) proposed a more elaborate alternative whereby the total cost of RES support is spread over all final fuel consumers in proportion to consumption. The author demonstrates that, as the EU target is for all RES energy, it would be both cost-effective, towards the achievement of the target, and equitable, across consumption of different fuels, to charge all forms of non-renewable energy.

In recent years, Italy has provided a striking example of rapidly rising RES-E investment and growing cost of the relative incentives. Different RES-E promotion schemes have been in operation, the costs of which are largely recovered through a specific surcharge called "Componente tariffaria A3" (A3). In the space of only few years, the rates of the A3 (c€/KWh), which vary both by user and consumption level, have gone from being negligible to sizable. Primarily due to the feed-in tariffs for photovoltaics, which saw an unprecedented investment boom in 2011, they have grown by more than a hundredfold between 2008 and 2013. At the time of writing (June 2013), the A3 has come to represent about 17% of the price paid by the average household.

Dealing with the Italian case, this work contributes to the emerging debate, in Europe, on cost allocation of RES-E support and the more general question of equity in the energy transition. Our analysis has two main objects. First, we assess the distributional incidence of the A3 on household budgets. Using micro-data from the 2011 Italian household expenditure survey, we estimate the cost of the A3 across income distribution. The household sector is segmented in total expenditure deciles, but intra-decile variation is accounted for too. Second, we examine the option of a carbon tax as a means for recovering the cost of RES-E support alternative to electricity surcharges. Our presumption, supported by the evidence of many empirical studies (e.g., Ekins *et al.* [2011], Callan *et al.* [2009], Tiezzi [2005], Barker and Kohler [1998]), is that motor fuel consumption increases with rising income more than home fuel consumption does. If so, recovering the costs of RES-E support through a carbon tax, which hits all fossil fuels, would be less regressive than it currently is with electricity surcharges. Using the same data, we thus simulate the distributional impact of a carbon tax equivalent in yield to the A3. Since both climatic and economic conditions vary significantly across Italy, thereby affecting the impacts of the carbon tax and the A3, the analysis conducted for the country is then replicated for three macro-regions.

Cingano and Faiella (2013) already showed that a carbon tax on motor fuels could replace the more regressive A3, given the different patterns of electricity and gasoline consumption across income distribution. We envisage a carbon tax that applies to all fossil fuels, which has further implications. A carbon tax on all fossil fuels, as opposed to only motor fuels, gives consumers more opportunities for behavioural change. Also, as motor fuels in Italy are already heavily taxed, spreading the burden over all fuels would be both more cost-effective (toward emission abatement) and politically practicable. More generally, we put forward the idea that the extension of carbon pricing to the non-EU ETS sector, recommended on the ground of cost-effectiveness, could also make the cost recovery of RES support less regressive, if the proceeds were used for that purpose. Not least, a fairer distribution of costs and tax earmarking should help a great deal to make the reform accepted.

The paper is organised as follows. Section 2 describes the recent development of renewable electricity in Italy as well as the support schemes underpinning it. Section 3 illustrates the A3, with respect to its rates, how they evolved over time and how this evolution is reflected in the structure of retail prices. Section 4 estimates the incidence of the A3 across income distribution and compares it to that of a carbon tax, both at the national level and for three macro-regions. Section 5 concludes.

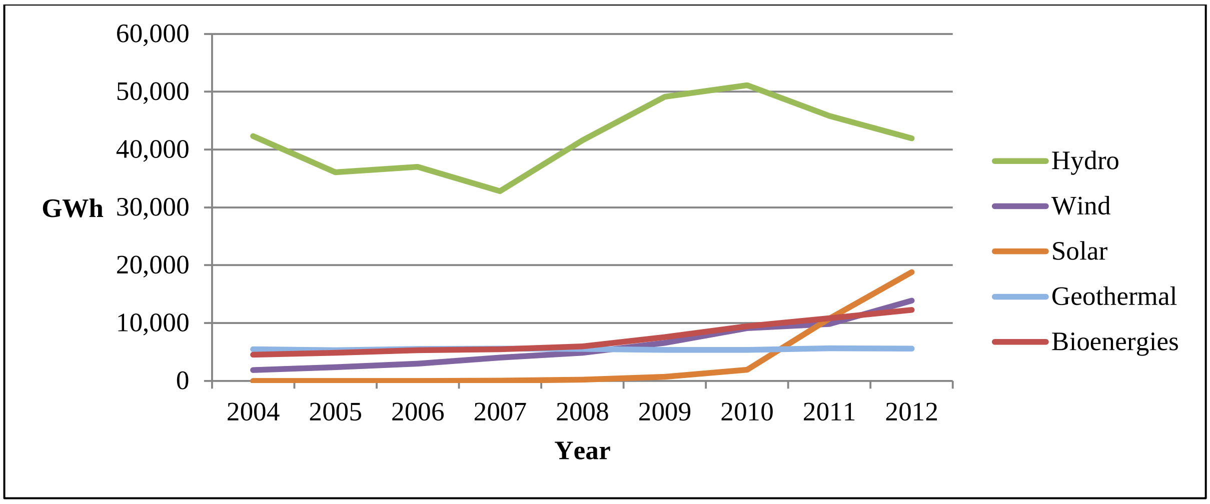
2. The progression of renewable electricity

2.1 Installed capacity and generation

Under the EU Renewable Energy Directive (28/2009), Italy must produce renewable energy for an amount equal to 17% of total energy consumption, by 2020. The National Renewable Energy Action Plan (NREAP) breaks down this target into three non-binding sub-targets, one for each of the following sectors: electricity, heating/cooling and transport. Most efforts, thus far, have been spent in supporting renewable electricity. In 2012, RES-E generation reached 27% of electricity consumption, less than 2 percentage points short of the relative NREAP target (28.9%).

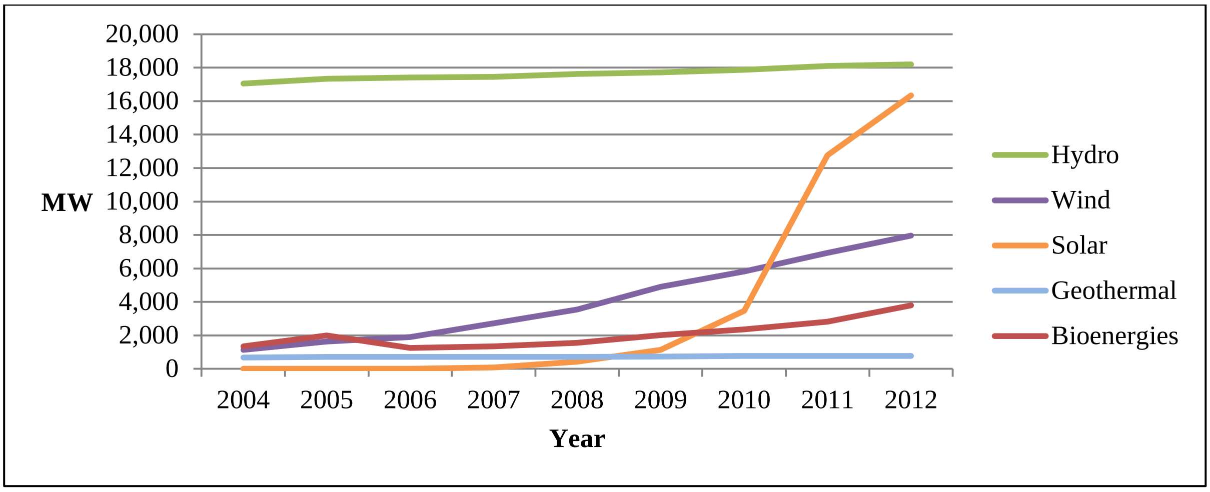
Different technologies contributed in different proportions to the progression of RES-E generation. It is apparent from Figure 1 that the period 2008-2009 was characterised by a sizeable increase in electricity produced by hydro power plants – an increase mostly due to more favourable weather conditions. The trend between 2010 and 2012, by contrast, was driven primarily by the investment boom in photovoltaics. "Boom" is not an overstatement: in 2011, newly installed photovoltaic capacity amounted to 9.3 GW, the world record that year. Figure 2 shows the patterns of cumulated capacity, by RES-E technology. Photovoltaic capacity exhibits almost a quadratic trajectory and is close to surpassing the capacity level of hydro. Both wind and bioenergies have been growing at virtually constant rates, but clearly the pace of the first has been faster.

Figure 1 – RES-E generation



Source: Terna (Italy's transmission system operator).

Figure 2 – RES-E installed capacity



Source: Terna

2.2 RES-E support mechanisms

Such an increase in RES-E generation materialised thanks to a variety of support schemes that were in operation. RES-E investment has been primarily incentivised through four generation-based mechanisms, namely "CIP 6/92", "Certificati Verdi", "Conto Energia" and "Tariffa Onnicomprensiva".[4] The first two are gradually being replaced by a tender system (Legislative Decree 28/2011), the cost of which, however, still will be recovered through the A3. For this reason, and because our analysis has an ex-post perspective, it suffices to focus on the four mechanisms above. A brief review of them follows:[5]

1. Introduced in 1992, CIP 6/92 (the acronym is from "Provision 6/1992 of the Inter-ministerial Committee on Prices") is the first program for the direct promotion of RES-E generation. It is a feed-in tariff scheme that guarantees eligible generators a preset price for up to 15 years. Eligible are not exclusively RES-E generators. Generation from so-called "assimilated (to renewable) sources", including co-generation, energy-from-waste and generation using fossil fuels from minor isolated deposits, is also incentivised. In fact, more than two thirds of the scheme's cost is for the support of assimilated sources. The scheme is being phased out, as no new contracts are going to be issued and those still in effect will expire within few years. Its cost, which is determined by the difference between the guaranteed price and the wholesale market price, is recovered through the A3.
2. Certificati Verdi, in force since 1999, is a tradable green certificates scheme whereby conventional generators are obliged to surrender certificates of renewable electricity (originally issued in exchange for RES-E generation) in proportion to production. For conventional generators, the certificates represent an additional cost, part of which may be absorbed and the remainder adds to the supply price. Therefore, the impact of green certificates on final consumers is filtered by the wholesale market, first, and the retail market, then. In the last few years, however, because of the recession, the market of green certificates has exhibited a

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4 Public funds granted to RES-E promotion, as investment contributions and tax expenditures (i.e., reductions in tax revenues due to preferential tax treatment), are not negligible, but very difficult to quantify. Different government levels are involved (European, national, regional, local) and, with reference to tax expenditures, no information is usually available on the number of those who took advantage of the benefit nor could this number be plausibly estimated.

5 For a detailed description of energy law in Italy, see Di Porto (2011). For a guide to the most recent legislation on RES-E support, see APER (2012a; 2012b).

persistent excess of supply. Unsold certificates are purchased by Gestore dei Servizi Energetici (GSE) and that cost is subsequently recovered through the A3.[6] As a result, in recent years the scheme has weighed for the most part on the A3. Certificati Verdi is coming to a close end too: as of 2013, no more certificates are issued and those still valid will expire by 2015.

3. Conto Energia is a feed-in tariff scheme exclusive to photovoltaics. It guarantees photovoltaic generators a fixed tariff for 20 years. The scheme has undergone several adjustments over the years, from “Conto Energia I”, in 2005, to “Conto Energia V”, in 2012. The cost of the scheme, which escalated in 2011 as a result of generous incentives and massive investment, is recovered through the A3. Conto Energia V set a €6.7b cap on the future annual cumulative cost of the scheme, which was reached in June 2013. As of then, new installations receive no feed-in tariff.
4. Tariffa Onnicomprensiva is a more recent feed-in tariff scheme, only for relatively small non-photovoltaic installations (less than 1 MW as a general rule, less than 200 KW only for wind). Eligible generators can choose between Tariffa Onnicomprensiva and Certificati Verdi. The cost of the scheme is recovered through the A3.

With reference to 2011, Table 1 shows the breakdown of incentivised RES-E generation, by technology and scheme. Across technologies, the Certificati Verdi scheme covers two thirds of incentivised RES-E generation. Across schemes, one third is from hydro, while photovoltaics, wind and bioenergies represent about 20% each.

Table 1 – Incentivised RES-E generation by technology and support mechanism, in 2011; GWh

	Certificati Verdi	**Conto Energia**	**Tariffa Onnic.**	**CIP 6/92**	*Total*	*Share (techn.)*
Hydro	15,298.2	-	664.4	11.1	15,973.6	0.33
Photovoltaic	3.5	10,411.3	-	-	10,414.8	0.21
Wind	9,178.5	-	4.4	465.0	9,647.9	0.20
Bioenergies	4,623.8	-	1,873.7	3,114.0	9,611.5	0.20
Geothermal	3,374.0	-	-	-	3,374.0	0.07
Total	32,478.0	10,411.3	2,542.4	3,590.1	49,021.8	1.0
Share (scheme)	0.66	0.21	0.05	0.07	1.0	

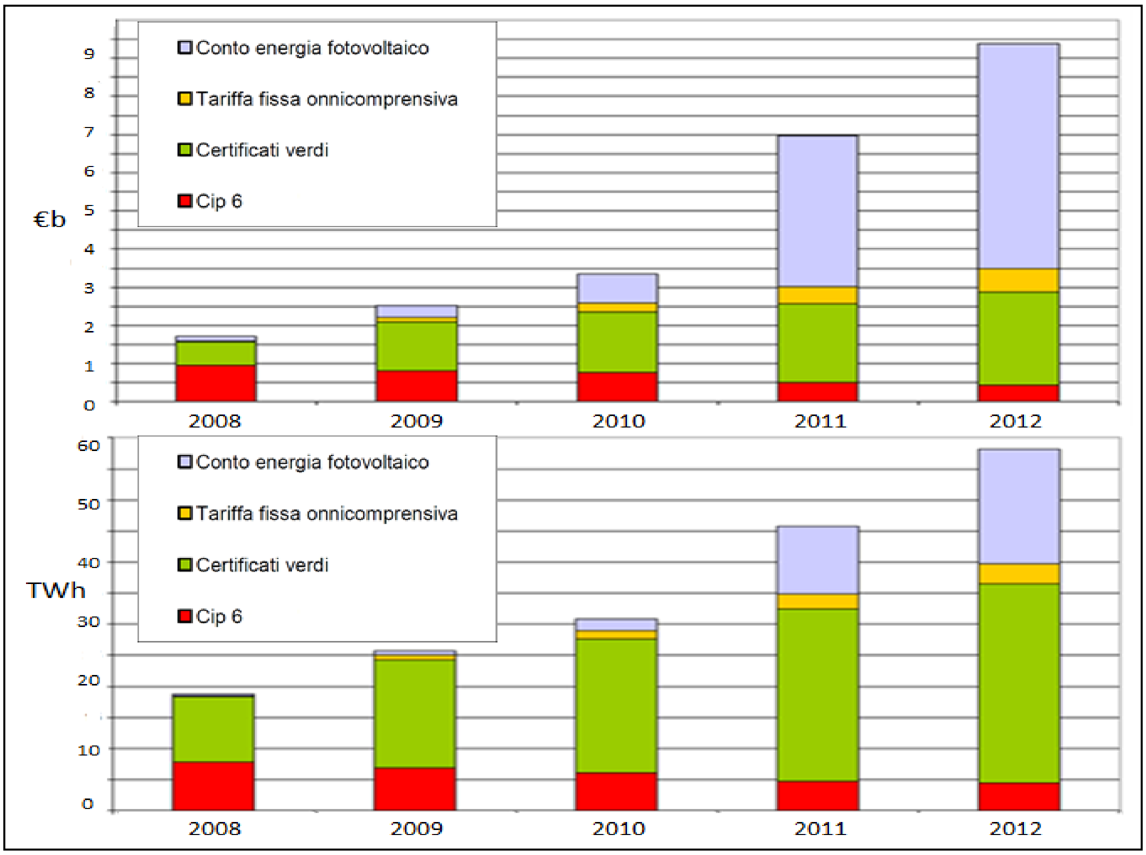
Source: GSE (2012).

Figure 3 shows the evolution of costs (upper chart) and generation levels (lower chart), under the four schemes, over the period 2008-2012. The development of photovoltaics, both in generation and cost, again catches the eye.[7]

6 The certificates in excess are bought by GSE, the following year, at a price determined as the sum of the annual average wholesale electricity price and a premium. The latter depends inversely on the former.

7 For Certificati Verdi, a cost-to-generation ratio based on this chart cannot be deduced as certificates issued at a given time are valid for three years thereafter.

Figure 3 – Cost of support mechanisms (upper chart) and RES-E generation (lower chart)



Note: The values for CIP 6/92 only refer to RES (assimilated sources are not considered); 2012 values are estimates.
Source: AEEG (2012a).

Table 2 reports the costs breakdown of RES-E support (excluding public funds and tax benefits) for 2011 as well as the corresponding estimates for the year after. Total costs are €7,337m and €10,002m, respectively. Of these costs, €6,637m and €9,252m (90% and 92%), in that order, are paid through the A3.[8] Moreover, under the Certificati Verdi scheme, €1,352m and €1,790m correspond to unsold green certificates (weighing on the A3), while traded certificates amount to €700m and €750m.

[8] The cost of CIP 6/92 incentives to assimilated sources, equally recovered through the A3 (but not qualifying as renewable), are €1,299m and €1,394m for 2011 and 2012, respectively.

Table 2 – Cost of RES-E support mechanisms; €m

RES-E support mechanisms	2011	2012
CIP 6/92	567	555
Certificati Verdi – Unsold cert's	1,352	1,790
Conto Energia	3,949	5,890
Tariffa Onnicomprensiva	464	603
Other	305	414
Total A3 (a)	6,637	9,252
Certificati Verdi – Negotiated cert's *(b)*	700	750
Total RES-E support mech. (a+b)	7,337	10,002

Note: The values for CIP 6/92 only refer to RES (assimilated sources are not considered); 2012 values are estimates.
Source: AEEG (2012b).

3. Cost recovery of RES-E support mechanisms

3.1 Household electricity prices

In 2004, the Italian electricity market was liberalised for medium- and high voltage users. Since 2007, low voltage users, including residential users (households), can choose whether to switch to the open market or stay in the regulated market. By 2012, about 20% of households had switched to the open market.

Retail electricity prices have three main components: *a)* the sale price of energy, *b)* tariffs, covering the costs of network- and system services, and *c)* taxes. Prices paid by households in the open market, P^O, only differ from those of the regulated market, P^R, with respect to the first component: in the open market, the price of energy is set by individual providers; in the regulated market, it is set by the market regulator.[9] Both tariffs and taxes are applied in the two markets without distinction. The three components, however, vary across different dimensions. With regard to residential users, they vary depending on the type of user (*h=1,2*), the level of annual consumption (*c = 1,2,3,4*) and the hour band of consumption (*t=1,2*). Specifically,

$$P^O_{hc} = \underbrace{P^S}_{\text{Price of energy}} + \underbrace{NS_{hc} + SS_{hc}}_{Tariffs} + \underbrace{ET_{hc} + VAT}_{Taxes} \quad [1]$$

$$P^R_{hct} = \underbrace{P^{AU}_{hct}}_{\text{Price of energy}} + \underbrace{NS_{hc} + SS_{hc}}_{Tariffs} + \underbrace{ET_{hc} + VAT}_{Taxes} \quad [2]$$

where: P^S is the price of energy demanded by supplier *S* in the open market; P^{AU} is the price of energy set by the regulator (the superscript reminds that the price is tied to procurement costs incurred by Acquirente Unico in the wholesale market); *NS* and *SS* are network services (transmission, distribution

9 The electricity sold in the regulated market is first purchased on the wholesale market by Acquirente Unico (Single Buyer), a publicly owned company. In the regulated market, the price of energy is tied to procurement costs incurred by Acquirente Unico, which are fully recovered.

and metering) and system services, respectively; *ET* and *VAT* are excise tax and value added tax (10%), respectively.[10]

Zooming in on the bimodal classification of residential users, relevant for our analysis, two parameters are considered: *a)* whether the dwelling is the place of residence of the account holder; *b)* whether the committed power capacity is greater than 3 KW. If the dwelling is not the place of residence of the account holder, the user is classified as "D3", regardless of the committed power capacity level. Conversely, if it is the place of residence and, also, the committed power capacity is not greater than 3 KW, the user is classified as "D2". That is,

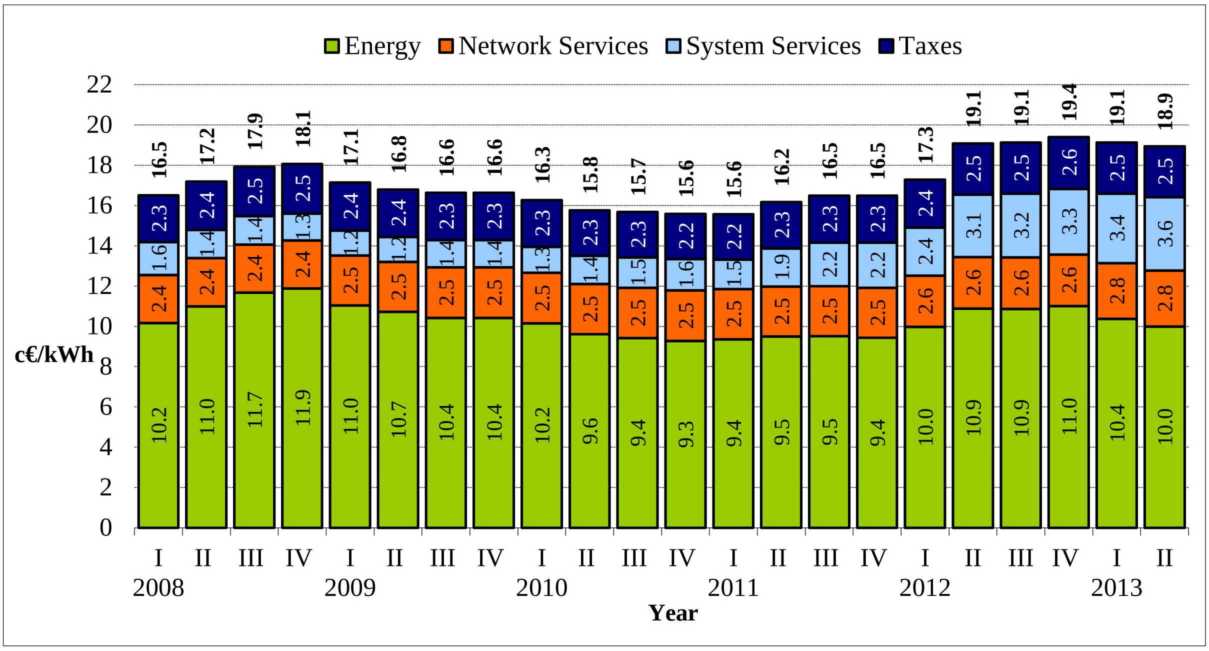
$$h\begin{cases} = \text{"}D2\text{"} & if \;\; \leq 3KW \cap \;\; place\, of\, residence \\ = \text{"}D3\text{"} & if \;\; > 3KW \;\; \cup \;\; not\; place\, of\; residence \end{cases}$$

[3]

3.2 The reflection of RES-E support in retail prices

The progressive expansion of the cost of RES-E support is visible in the changing composition of retail prices. Every three months, the market regulator publishes the breakdown of the price paid by the representative residential user in the regulated market (as per [2]), identified as a "D2" with 2,700 KWh annual consumption. Figure 4 assembles these figures from 2008 to 2013. Table 3 contrasts prices in the first quarters of 2008 and 2013. The relative weight of system services, 90% of which has come to be represented by the A3, almost doubled between 2008 and 2013: from 9.9% to 18%.

Figure 4 – Composition of electricity price paid by the representative residential user, 2008-2013



Source: AEEG.

[10] In [1] and [2], the VAT yield is additive, but the VAT rate is applied to (multiplied by) all other elements of the equation.

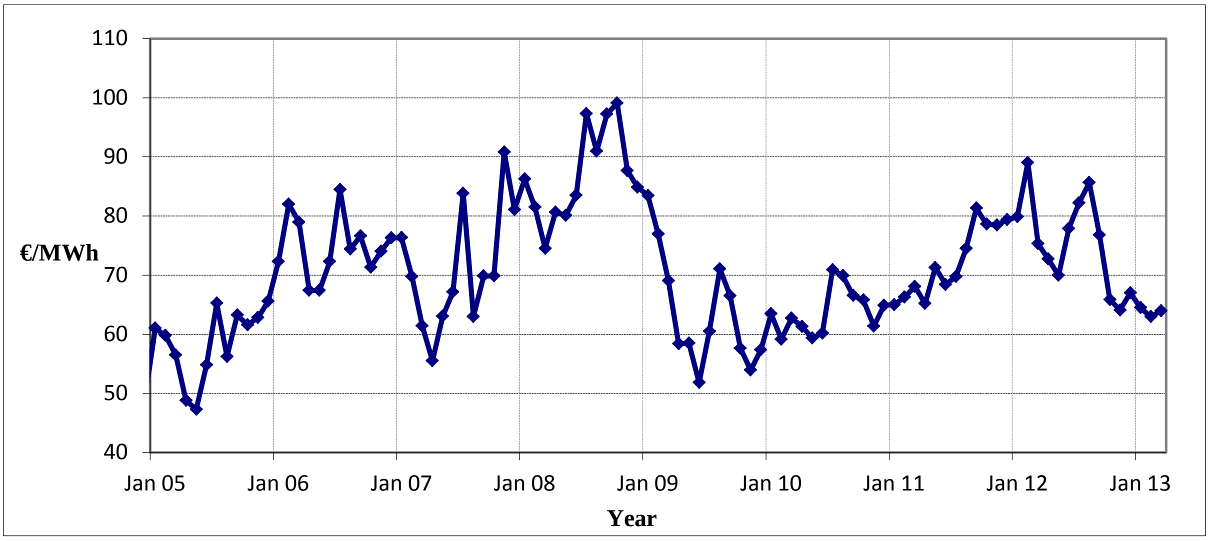
Table 3 – Price paid by the representative residential user: 2008 Q1 vs 2013 Q1

	2008 Q1		2013 Q1	
Component	c€/KWh	%	c€/KWh	%
Energy (procurem. and sale)	10.16	61.6%	10.38	54.3%
Network Services	2.39	14.5%	2.77	14.5%
System Services	1.63	9.9%	3.44	18.0%
Taxes	2.33	14.1%	2.55	13.3%
Total	16.51	100.0%	19.13	100.0%

Source: AEEG.

Greater RES-E generation means that the overall cost of the connected support schemes rises, as is reflected by the swelling of the A3 over time. This explains the difference in the cost of system services between 2008 and 2013. At the same time, however, as the variable cost of RES-E generation is virtually nil, greater penetration of renewable electricity should lower wholesale prices – what is technically known as merit-order effect. As a result, the net impact on retail prices is intended to be smaller than the A3 itself.[11] It is the case that the wholesale price, Prezzo Unico Nazionale (National Single Price), in the first quarter of 2013 was 20% lower than it was in the first quarter of 2008 (Figure 5).[12] However, without a model of the market it is not possible to tell how much of this difference can be attributed to the greater share of renewable electricity in the generation mix.

Figure 5 – Electricity wholesale price (Prezzo Unico Nazionale), 2005-2013



Source: AEEG.

3.3 The structure of the A3

Different rates of the A3 are applied across user categories and consumption levels. They are regularly revised (usually every three months) by the market regulator, Autorità per l'Energia Elettrica e il Gas (AEEG), in function of the costs that need to be recovered. As a result of the surge in RES-E

11 Lehr *et al.* [2012] and Cludius *et al.* [2013] estimate the net cost of the surcharge for German consumers.

12 The National Single Price is the weighted average of zonal prices in the day-ahead market. Not to be confused with P^{AU}, in [2], though to some extent the second should reflect the first.

investment, of photovoltaics in the first place, these rates have grown by more than a hundredfold between 2008 and 2013.

Tables 4 and 5 report the rates of the A3 applied to residential and industry users, respectively, in the first quarter of 2008. The A3 was then still very modest and virtually uniform across users. The same rate, c€0.03/KWh, was applied to all levels of household consumption as well as to industry monthly consumption below 8 GWh. The two exceptions to the rule were: *a)* monthly consumption above 8 GWh, of medium-, high- and very high voltage users, was tariff-exempt; *b)* a slightly higher rate, c€0.04/KWh, was applied to all consumption of low voltage non-residential users (with more than 1.5 KW committed power capacity).

Table 4 – A3 rates for residential users, in 2008 Q1

	Annual consumption (KWh)		
User type	< 1800	1800 - 2640	> 2640
D2	0.030	0.030	0.030
D3	0.030	0.030	0.030

Source: AEEG.

Table 5 – A3 rates for industry users, in 2008 Q1

	Monthly consumption (GWh)			
Voltage	< 4	4 - 8	8 - 12	> 12
Low (< 1.5KW)	0.03	-	-	-
Low (> 1.5KW)	0.04	0.04	0.04	0.04
Medium	0.03	0.03	0	0
High, Very High	0.03	0.03	0	0

Source: AEEG.

Thereafter, all rates have been progressively raised and differentiated at the same time. Tables 6 and 7 show what they looked like five years later, in the first quarter of 2013. For D2 residential users, three consumption brackets are applied different rates. Specifically, c€2.346, c€3.522 and c€5.102 per KWh apply to annual consumption, respectively, below 1,800 KWh, between 1,800 and 2,640 KWh, and above 2,640 KWh. For D3 residential users, a single rate exists, which is also the highest, c€5.102/KWh. Turning to producers, low voltage users remain the most penalised (c€4.745/KWh is applied to all consumption), while lower rates and exemptions (above 8- or 12 GWh monthly consumption) apply to consumption of medium-, high- and very high voltage users.

Table 6 – A3 rates for residential users, in 2013 Q1

	Annual consumption (KWh)		
User type	< 1800	1800 - 2640	> 2640
D2	2.346	3.522	5.102
D3	5.102	5.102	5.102

Source: AEEG.

Table 7 – A3 rates for industry users, in 2013 Q1

	Monthly consumption (GWh)			
Voltage	< 4	4 - 8	8 - 12	> 12
Low (< 1.5KW)	3.475	-	-	-
Low (> 1.5KW)	4.745	4.745	4.745	4.745
Medium	3.896	3.896	0	0
High, Very High	3.924	1.962	1.962	0

Source: AEEG.

The magnitude of these rates is notable if compared to the wholesale electricity price, which in the first quarter of 2013 averaged c€6.4/KWh (Figure 5). As the rates are so high and diverse, the ensuing distributional effects, across households and firms, are non-negligible. Table 8 shows the distribution of residential users by market (regulated, open) and level of the A3 (low, medium, high), in 2011.[13] More than half of all residential users (52%) pay the highest rate. Among these, there are both D2 users with annual consumption exceeding 2,640 KWh and D3 users (with any consumption level).

Table 8 – Distribution of residential users by market and A3 level; thousand

	A3 rate level				
Market	Low	Medium	High	*Total*	*Share*
Regulated	7,156.7	4,581.1	12,278.1	24,015.9	83.3%
Open	1,044.6	1,058.6	2,710.2	4,813.4	16.7%
Total	8,201.3	5,639.7	14,988.3	28,829.3	
Share	28.4%	19.6%	52.0%		100.0%

Source: Authors' calculations based on AEEG data.

As regards non-residential users, the tariff structure is advantageous to big electricity consumers and disadvantageous to small or relatively small ones (Table 7). Thus, while the rates applied to residential users somehow reflect the principle of progressiveness, those applied to non-residential users were set to safeguard the competitiveness of the largest electricity consuming industries. In this regard, however, a recent ministerial decree ordained that these rates must be revised according to industries' electricity intensity (relative to turnover) and not just on the basis of consumption level.[14]

3.4 The "Bonus Elettrico" (Social Bonus)

The most vulnerable in society to rising energy bills are usually helped through specific income supplements. Depending on how well-targeted they are, these compensatory measures more or less effectively adjust the distributional impact of electricity price rises. In Italy, the "Bonus Elettrico" (Social Bonus) is a program, in place since 2008, for aiding indigent households and those dependent on electrical medical equipment covering the cost of electricity consumption. The amount of the Bonus depends on the size of the household and is meant to represent about 20% of the expected annual electricity expenditure. All electricity consumers, except the beneficiaries, pay a specific surcharge for recovering the cost of the program. This, cumulated over the period 2008-2012, has been

[13] For the open market, only the distribution of consumption is available. We thus assumed that the proportions of D2 and D3 users were the same as in the regulated market (for which information is available).

[14] The decree was issued in conjunction by the Ministry of Economy and Finance and the Ministry of Economic Development, on April 5th 2013.

estimated to amount about €300m. About two million households have received the Bonus at least once since its introduction and about 950,000 households received it in 2012 (AEEG [2013]).

4. Distributional incidence: A3 vs carbon tax

In this section, we estimate the incidence of the A3 (c€/KWh) across income distribution and compare it to that of a carbon tax (€/tCO_2) as a potential alternative for recovering the cost of RES-E support. The primary aim is to determine whether, and to what extent, a carbon tax would be less regressive than the A3. The tax envisaged applies to all CO_2 emissions. It is thus equivalent to one that only applies to the non-EU ETS sector and perfectly matches the carbon price in the EU ETS sector – a uniform price on all emissions is the first-best option for emission abatement. In general, a carbon tax "directly" impacts on CO_2-related energy prices, including electricity prices, and "indirectly" on all other prices. In comparing the carbon tax to the A3, we only consider the direct impact.[15] The carbon tax we derive is such that *a)* applied to CO_2 emissions from household consumption of motor fuels, electricity, gas and other home fuels, and *b)* assuming perfectly inelastic demand, it generates a yield equal to the estimated cost of the A3 for the same households.[16] This allows us to compare the carbon tax and the A3 with respect to distributional incidence. Furthermore, as Italy's territory is characterised by significant economic and climatic variation, the analysis is first carried out for the country as a whole and, then, for three macro-regions – Northern, Central and Southern Italy.

The fundamental difference between the carbon tax and the A3 is in the base. The first hits all forms of CO_2-related energy, while the second only concerns electricity consumption. Thus, to the extent that energy is a less necessary good than electricity, the carbon tax will be less regressive than the A3. Indeed, we expect this to be the case, as the demand for home fuels is typically less income elastic than the demand for motor fuels; and, in line with this, we usually observe that motor fuel consumption more closely follows income, across income distribution, than electricity consumption does. It is understood that this has to do with the number and the engine size of vehicles owned by richer households.

4.1 Data and methodology

Every year, the Italian statistical office (Istituto Nazionale di Statistica) conducts a household survey called "Indagine sui consumi delle famiglie" (ICF). The survey records monthly expenditures as well as information on socio-demographic characteristics and other variables. We use the most recent round presently available, which refers to 2011 and has a sample of 23,158 households (ISTAT [2013]).[17] Unfortunately, the ICF does not report information on quantities consumed.[18] The data, however, are sufficiently detailed with respect to the goods purchased. This is true also for energy items, which is what we focus on. Where suitable averages of consumer prices are available (from external sources), we are thus able to estimate quantities by dividing expenditures by the relative price averages. In our application, the energy commodities for which consumer price averages were available are electricity, natural gas, home heating diesel, petrol and transport diesel. The respective values are reported in Table A1, in the Appendix.

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[15] The direct impact is more significant in terms of magnitude. It is also easier to estimate. To estimate the indirect impact, the carbon content of final products needs to be determined. This is typically done using input-output data in combination with emissions data (e.g., Verde and Tol [2009], Wier *et al.* [2005]).

[16] The equivalence in yield is limited to the household sector. To impose the equivalence in total yield, an economy-wide model is needed.

[17] In 2011, Italy's household population was 25,165,002.

[18] We urge ISTAT to introduce quantities of energy commodities in the ICF. This would enhance both scope and quality of empirical studies dealing with household energy consumption.

We carry out distributional (incidence) analysis based on consumption patterns across income distribution. As the survey does not report information on household disposable income, we use total expenditure as a proxy.[19] The sample is partitioned by adult-equivalised total expenditure decile so as to take differences both in households' size and composition into account.[20] Besides, sample weights are applied throughout, which means that the total expenditure deciles as well as the relative statistics represent population parameters.

For each household, the cost of the A3 is given by the product of electricity consumption and the relative rates. As the ICF refers to 2011, we apply the A3 rates in force at the time. These were already relevant in magnitude (Table 9), but are substantially lower than current ones (Table 6).

Table 9 – A3 rates for residential users, in 2011

		Annual consumption (KWh)		
Quarter	**User type**	< 1800	1800 - 2640	> 2640
Q1	D2	0.491	0.736	1.006
	D3	1.006	1.006	1.006
Q2	D2	0.965	1.447	2.097
	D3	2.097	2.097	2.097
Q3	D2	1.162	1.743	2.526
	D3	2.526	2.526	2.526
Q4	D2	1.262	1.893	2.744
	D3	2.744	2.744	2.744

Source: AEEG.

The results below are, therefore, specific to 2011. The main purpose of this application, however, is to assess the difference in distributional incidence between the A3 and the carbon tax. In that respect, the conclusions are valid not just in relation to that specific year, but in a more general sense. Furthermore, for each household, the ICF only allows us to estimate – and not to derive without error – the cost of the A3. There are two reasons for this. First, information on electricity consumption (quantity) is not given. We thus estimate it by dividing expenditure by a suitable price average. Second, after estimating monthly consumption, we need to estimate annual consumption. This is because different A3 rates apply to different brackets of annual consumption. We then have to extrapolate each household's annual consumption based on the pattern of average monthly consumption (estimated).[21]

The estimates we worked out are largely consistent with aggregate statistics on household electricity consumption. Figure 6 shows the distribution of annual electricity consumption obtained with the procedure just described. The median, 2,606 KWh, is very close to 2,700 KWh, which is the consumption of the representative household (in the regulated market) indicated by the market regulator (AEEG). The distribution of households by A3 rate (Table 10) is also in line with the actual one (Table 8).

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[19] This was an obligated choice. However, it is often presented as a preferable option, by the arguments of *a)* total expenditure being a better measure of permanent income, and *b)* income underreporting in household surveys.

[20] We use the new OECD equivalence scale, whereby the head of household weighs 1, all other household members aged 14 or older weigh 0.5 each, and those younger than 14 weigh 0.3 each. Adult-equivalised total expenditure is then obtained by dividing total household expenditure by the sum of equivalised adults.

[21] As the pattern differed somewhat for households with air conditioning equipment, we derived one separately for that subsample.

Figure 6 – Distribution of households by annual electricity consumption.

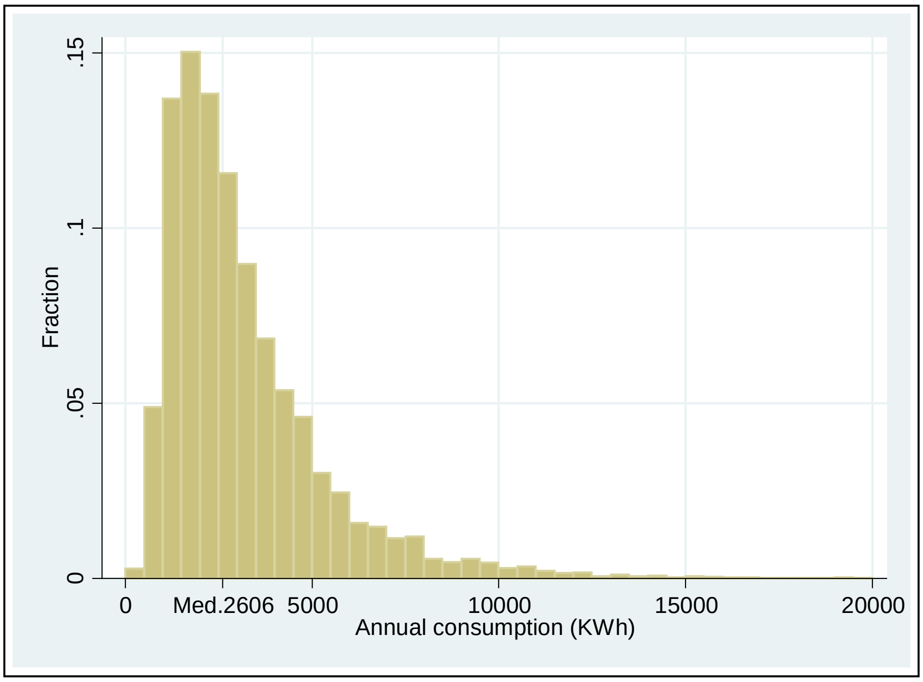


Table 10 – Distribution of households by A3 level and tot. expend. decile.

	A3 rate level			
Decile	Low	Medium	High	*Total*
1st	32.5%	23.2%	44.3%	100%
2nd	28.0%	22.5%	49.5%	100%
3rd	26.5%	24.2%	49.4%	100%
4th	27.9%	22.9%	49.2%	100%
5th	24.1%	23.6%	52.3%	100%
6th	25.0%	23.0%	52.0%	100%
7th	26.4%	22.6%	51.0%	100%
8th	25.1%	22.5%	52.4%	100%
9th	25.1%	18.6%	56.3%	100%
10th	23.1%	13.8%	63.1%	100%
All pop.	26.4%	21.7%	51.9%	100%

If we sum and gross-up estimated consumption to derive overall consumption of the household sector, in 2011, we get 83,900 GWh, which is 19% above the actual amount, 70,140 GWh. Some discrepancy between monthly survey data and annual aggregate data is normal. However, the main reasons why overall consumption is here overestimated are: *a)* the ICF does not tell us whether the given household is a D2 or a D3 user nor whether it buys electricity in the regulated market or in the open market;[22] *b)* we only had information on average quarterly prices for D2 users, in the regulated market. We thus had no alternative but to apply D2 average prices to all electricity expenditures, even though D3 users generally pay higher prices. Moreover, in 2011, average retail prices were about 20% higher in the open market than in the regulated market (AEEG [2012c]).

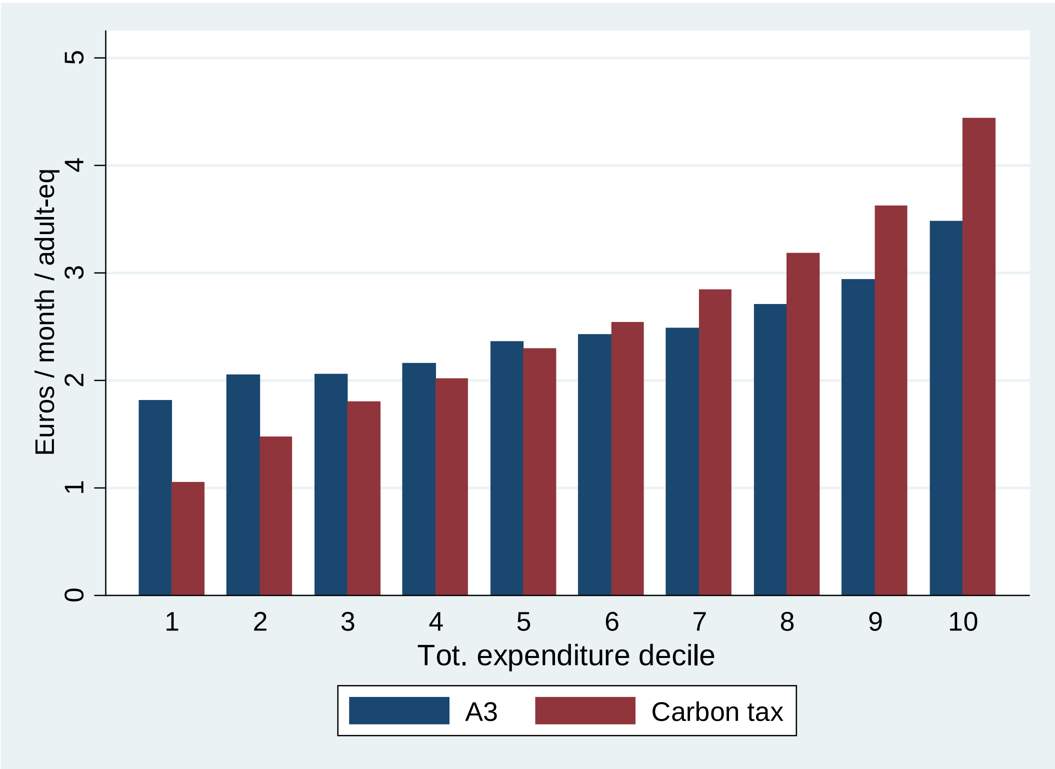
[22] The only useful distinction is between first and second homes.

The higher (electricity consumption and, thus) the yield of the A3 is, the higher the equivalent carbon tax is. The rate of the carbon tax is determined by dividing the overall yield of the A3 (estimated) by the overall amount of CO_2 emissions (estimated), both limited to the household sector. In asserting the equivalence in yield, between the A3 and the carbon tax, the implicit assumption is that household energy demand is unresponsive to the second, which is a reasonable assumption only for the very short term. Emissions embedded in energy consumption are obtained by multiplying the estimated quantities of fuels and electricity by the respective emission factors (Table A2).

4.2 Results: whole country

The carbon tax rate, equivalent to the A3 in the sense previously specified, turned out to be €8.6/tCO_2. We then multiplied this rate by each household's emissions to work out the cost of the tax for each of those. As Figure 7 shows, average costs both of the A3 and of the carbon tax increase monotonically across income distribution.[23] The pattern of the first, however, is flatter. The average monthly cost of the A3 is slightly less than €2 per adult equivalent (€/month/adult-eq), for the first decile, and about €3.5 for the tenth decile. The average cost of the carbon tax, instead, ranges between €1 and almost €4.5/month/adult-eq.

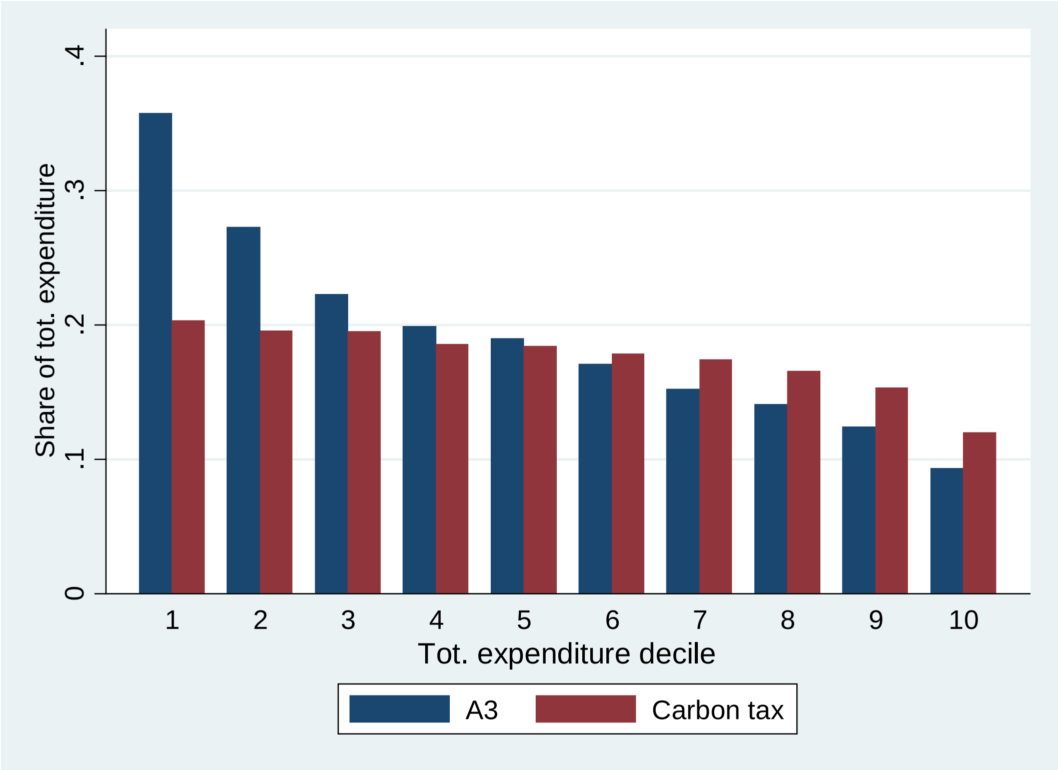
Figure 7 – A3 vs carbon tax: cost (average), by tot. expend. decile.



We compared these costs to total expenditure in order to better appreciate the magnitude of the effects and assess the incidence of the two instruments. As Figure 8 shows, on average, the cost of the A3 represents slightly more than 0.35% of total expenditure, for the first decile, and slightly less than 0.1%, for the tenth decile. By contrast, the cost of the carbon tax represents 0.2% of total expenditure, for the first decile, and little more than 0.1% for the tenth decile. Therefore, the first-to-tenth decile ratios are slightly above 3.5 and 2, for the A3 and the carbon tax, respectively. This means that the first is significantly more regressive than the second.

[23] The distribution is, in fact, of adult-equivalised total expenditure.

Figure 8 – A3 vs carbon tax: share of tot. expend. (average), by tot. expend. decile.



A limitation of this way (standard) of assessing regressiveness is that it ignores intra-group (in this case, intra-decile) variation. We therefore reproduced the charts in Figures 7 and 8 but replaced the bars with box plots marking the first, second and third quartiles (Q1, Q2 and Q3) and the adjacent values of the distributions.[24] It is apparent, in Figures 9 and 10, that the incidence of the carbon tax is less variable than that of the A3. This is a second important point in favour of the former, as it implies a more even – not only less regressive – distribution of the cost. Table 11 reports the coefficient of variation, by decile, both for the A3 and the carbon tax.

[24] The adjacent values are defined as the lowest and highest observations that are still inside the region defined by the following limits (lower and upper limit, respectively): *a)* Q1-1.5·IQR and *b)* Q3+1.5·IQR, where IQR is the interquartile range, Q3-Q1.

Figure 9 – A3 vs carbon tax: distribution of cost, by tot. expend. decile

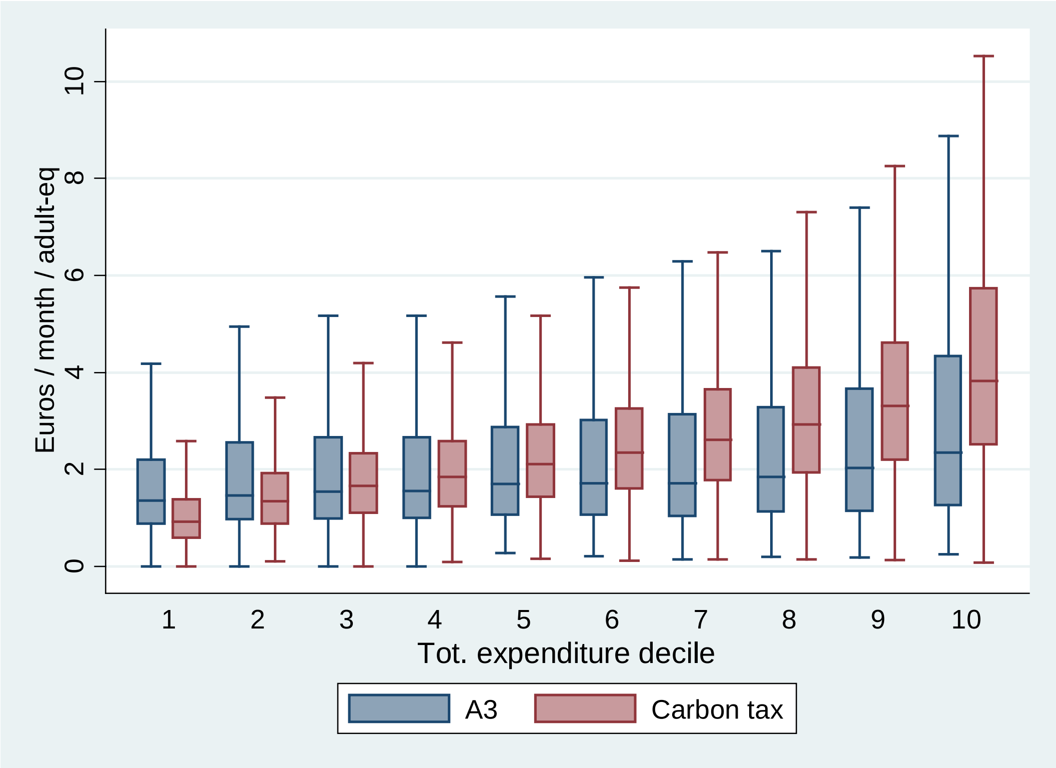


Figure 10 – A3 vs carbon tax: distribution of share of tot. expend., by tot. expend. decile

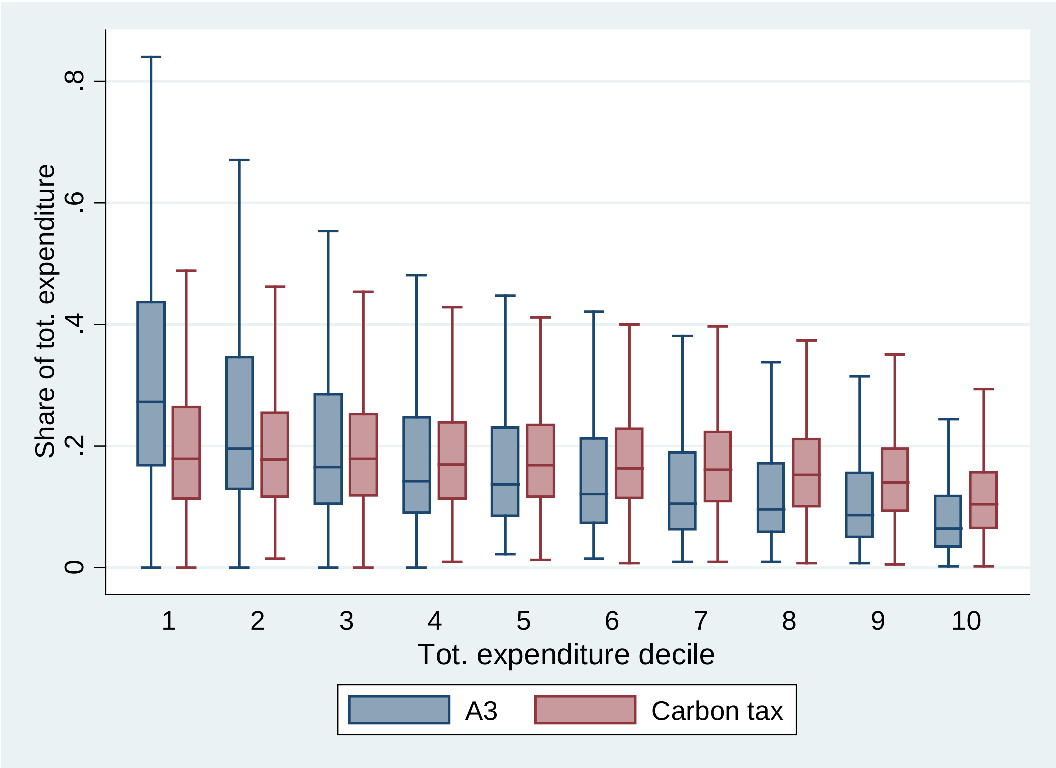


Table 11 – A3 vs carbon tax: coeff. of variation of cost and share of tot. expend., by tot. expend. decile

	Cost, € CV		**Prop. of tot. expend., %** CV	
Decile	A3	CT	A3	CT
1	0.86	0.64	0.86	0.60
2	0.89	0.57	0.89	0.56
3	0.81	0.55	0.81	0.55
4	0.87	0.56	0.87	0.56
5	0.90	0.54	0.90	0.54
6	0.91	0.54	0.90	0.54
7	0.93	0.56	0.93	0.56
8	0.95	0.56	0.96	0.56
9	0.97	0.56	0.97	0.56
10	1.08	0.65	1.05	0.67

4.3 Results: macro-regions

Economic and climatic differences between Italy's northern and southern regions suggest that the distributional incidence both of the A3 and the carbon tax may vary significantly within the country. We thus considered three macro-regions, namely Northern, Central and Southern Italy, and, for each of these, we replicated the analysis illustrated in the previous paragraph. The only difference is that the equivalence in yield, between the A3 and the carbon tax, still holds at the national level and not necessarily (in fact, very possibly) at the macro-regional level. This reflects the idea that the A3 and the carbon tax is and would be, respectively, uniform across the country.

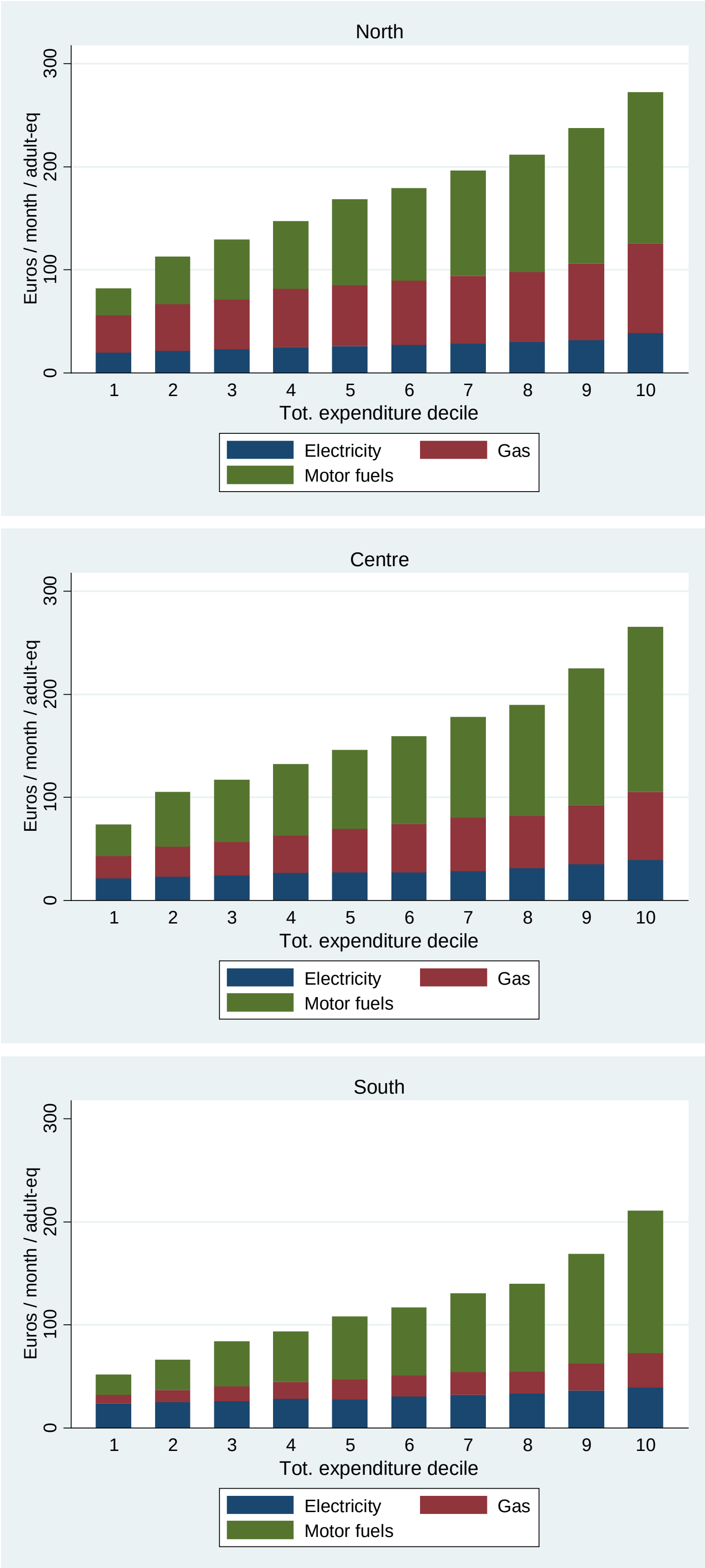
Table 12 reports the deciles of total expenditure (adult equivalised) derived for the three macro-regions. Income distributions of Northern and Southern Italy stand at opposite ends, while Central Italy lies in between.

Table 12 – Distribution of total expenditure, by macro-region; €/month/adult-eq.

Decile	North	Centre	South
1	< 831	< 763	< 525
2	831 – 1,040	763 – 948	525 – 649
3	1,040 – 1,208	948 – 1,111	649 – 754
4	1,208 – 1,382	1,111 – 1,255	754 – 867
5	1,382 – 1,557	1,255 – 1,413	867 – 982
6	1,557 – 1,766	1,413 – 1,605	982 – 1,115
7	1,766 – 2,050	1,605 – 1,861	1,115 – 1,279
8	2,050 – 2,425	1,861 – 2,127	1,279 – 1,505
9	2,425 – 3,145	2,127 – 2,659	1,505 – 1,925
10	> 3,145	> 2,659	> 1,925

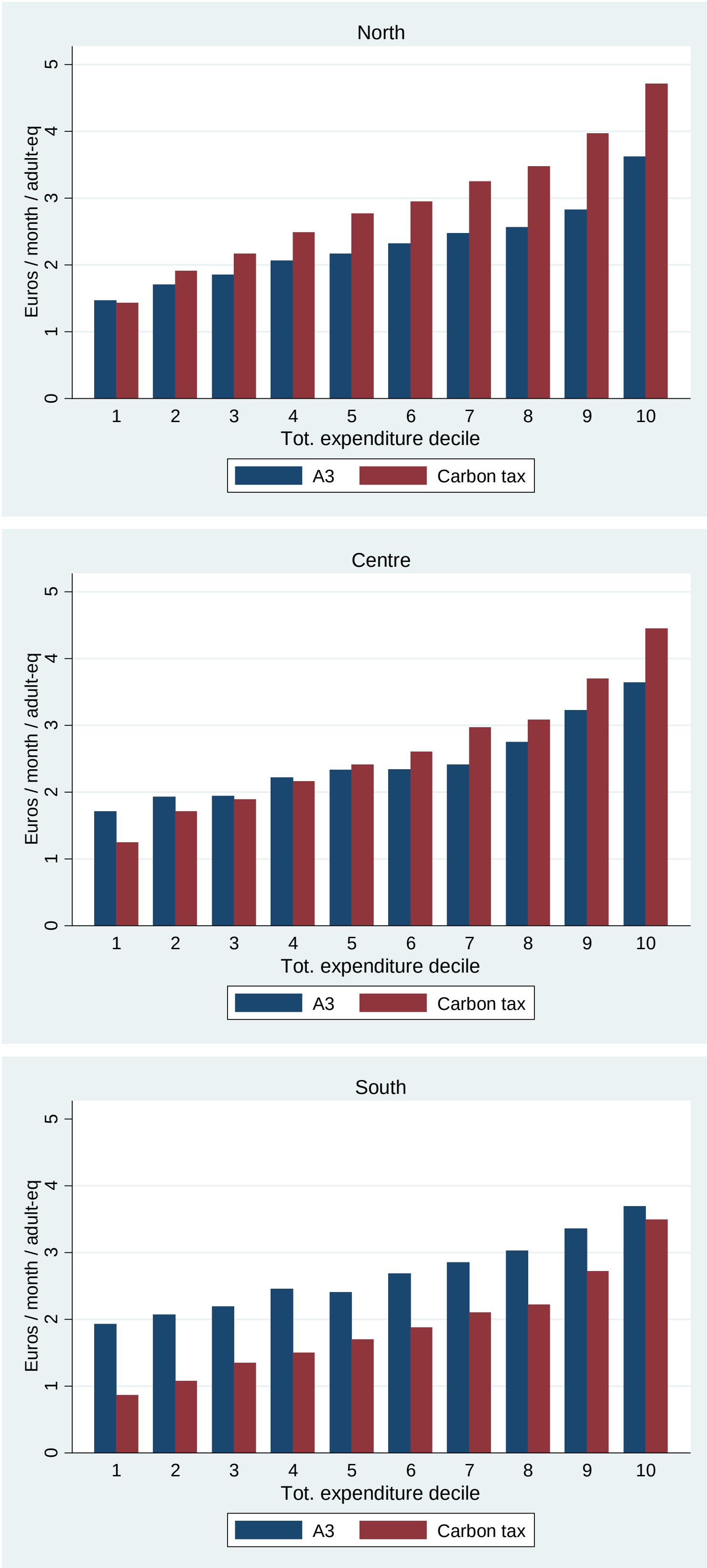
Both level and composition of energy expenditure significantly vary by macro-region too. Again, the biggest differences are between northern and southern regions, as Figure 11 shows. Energy expenditure largely follows income. It is highest in Northern Italy and clearly lower in Southern Italy. More surprisingly, perhaps, the composition of energy expenditure is quite different as well. In particular, substantially higher gas expenditure in Northern Italy, compared to Central and especially Southern Italy, suggests home heating weighs significantly more on households located in northern regions. By contrast, the levels both of motor fuel expenditure and electricity expenditure are comparable across regions.

Figure 11 – Energy expenditure (average), by total expenditure decile and macro-region



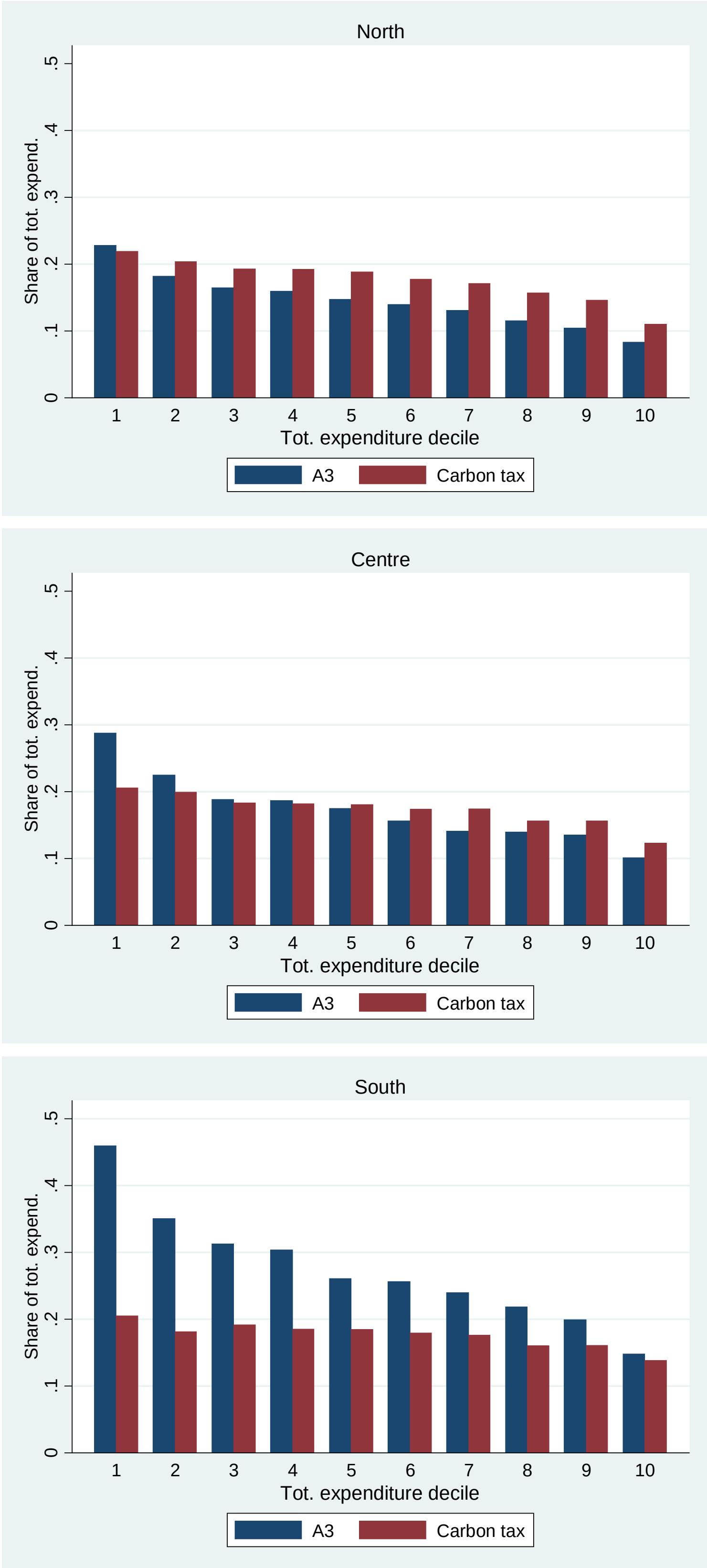
The differences just highlighted, in income distribution and expenditure patterns, underlie those in the incidence of the A3 and the carbon tax, as depicted in Figures 12 and 13. In Northern Italy, it emerges from Figure 12, the carbon tax is on average more onerous than the A3 across all income distribution but for the poorest decile. Exactly the opposite is true for Southern Italy, principally because of lower gas consumption, while Central Italy again exhibits an intermediate profile.

Figure 12 – A3 vs carbon tax: cost (average), by tot. expend. decile and macro-region



By expressing costs as proportions of total expenditure, we can compare burdens both within and between income distributions of the three populations. The A3 is generally more regressive than the carbon tax, but to a much greater extent in Southern Italy than in the rest of the country. The difference in distributional incidence, between the A3 and the carbon tax, indeed appears small both in Central and Northern Italy. Moreover, not only the carbon tax is generally less regressive than the A3 (especially in Southern Italy), but the burden it places is also much more homogeneous across the three macro-regions. In all of these, it ranges between 0.2% and 0.1%, for the poorest and the richest deciles, respectively. While income in Southern Italy is lower than in the other regions, electricity consumption is not lower in the same proportion. This is why the A3 is particularly penalising for the South. By contrast, gas consumption in Southern Italy is substantially lower than in the other regions. Because the carbon tax hits all fossil fuels, this makes up for the difference in income with the other regions.

Figure 13 – A3 vs carbon tax: share of tot. exp. (average), by tot. exp. decile and macro-region



In principle, assuming no solidarity among regions, Northern regions would prefer the A3 because it would cost them less (though its incidence is slightly more regressive than that of the carbon tax). This is because equality in yield between the A3 and the carbon tax is made to hold at the national level and Southern regions contribute more to the A3 than they do to the carbon tax total yield. As southern regions are poorer than the others, this result still is consistent with the argument that a carbon tax is less regressive than an electricity surcharge because energy is a less necessary good than electricity. It shows, however, how the application of the instruments in question can have different implications at the regional level.

5. Conclusions

This paper investigates the incidence, across income distribution, of the electricity surcharge used for recovering the cost of RES-E support in Italy. Following massive RES-E investment, primarily in photovoltaics, the surcharge in question, named A3, has gone up by more than a hundredfold between 2008 and 2013 and has come to represent about 17% of the price paid by the average household. What justifies RES-E support is a set of public policy objectives, including environmental protection, technology innovation, energy security and employment. Thus, in principle, its cost should be covered by the government budget. That RES-E support is instead funded by a surcharge on electricity consumption is questionable because of the regressiveness of such a system. Electricity is indeed a necessity good par excellence. The problem arises not just for Italy, but for most European countries, where RES-E support is funded in analogous ways.

We thus consider a carbon tax as a means for recovering the cost of RES-E support alternative to the A3. The tax applies to all CO_2 emissions and can be thought of as an extension of the carbon price to the non-EU ETS sector. A uniform price on all emission is recommended on the ground of cost-effectiveness in emission abatement, but – we argue – it would also make for greater equity if the proceeds were used in substitution of the A3. The fundamental difference between the A3 and the carbon tax is in the base: it is electricity in the former's case and (all fossil fuels, hence) all forms of CO_2-related energy in the latter's. The evidence of many studies (demand elasticities and consumption patterns) suggests that energy is a less necessary good than electricity; typically because motor fuel consumption more closely follows income than electricity consumption does. This is why a carbon tax would be less regressive than the A3.

Our empirical investigation, based on household survey data, confirmed this postulation. Not only that, the cost of the carbon tax would be more evenly distributed, which is a consequence of the fact that the base is diversified (unlike with the A3). Furthermore, differences in wealth and climatic conditions (thereby in energy use) determine regional differences in the impacts, measured as proportions of total expenditure, of the A3 much more than of the carbon tax. The impact of the A3 is about twice as big for southern regions compared to northern ones. By contrast, given lower gas consumption in the South, the carbon tax would impact similarly across the country. This can be regarded as a coincidence (it just so happens that gas consumption is lower in the South), but again it can only arise because the base of the carbon tax is diversified.

The reform we advocate *a)* has no cost (it shifts a burden, it does not add a new one), *b)* is for achieving greater equity (as well as cost-effectiveness) and *c)* involves tax earmarking. Taken together, these three elements should help making it accepted by the public. As a carbon tax would be more visible to the consumer than the A3 is, the replacement of the second with the first should be made equally visible. Strong empirical evidence confirms that earmarking the revenues from environmental taxes increases their popularity (e.g., Kallbekken et al. [2011], Kallbekken and Sælen [2011], Hsu *et al.* [2008], Dresner *et al.* [2006]). Furthermore, some accompanying measures would be needed. Motor fuels, in Italy, are already heavily taxed, well above the European average.[25] A €20/tCO_2 carbon tax would only raise the price of petrol by about 4.5 cents/litre (5 cents for diesel),[26] but some discontent is easy to imagine. This could be overcome by reordering the existing set of energy taxes. Indeed, the system of excise taxes, across fuels and uses, has developed over the years in function of revenue needs and not for achieving cost-effective reductions in CO_2 emission. As a result, there is sufficient space for restructuring of excise taxes for accommodating a carbon tax on motor fuels while not raising prices by the same amount (OECD [2013]).

Finally, our empirical analysis is both static and limited to the household sector. This suffices for the purpose of showing the fundamental difference in distributional incidence between an electricity surcharge and a carbon tax. However, to give more precise indications about the proposed reform (beginning with the level of the carbon tax equivalent to the surcharge) and to take the effects on the rest of the economy into account, an economy-wide model would be needed. It is our intention to extend the study in this direction.

[25] In 2012, the price of diesel was 28% higher than the average for the twelve MS of the original Euro area. As for petrol, the price was 12% higher. (Source: Eurostat)

[26] A €20/tCO_2 carbon tax means 2 cents per kilogram of CO_2 (c€2/KgCO_2). As the emission factor of petrol is approximately 2.33 KgCO_2/litre (see Table A2, in the Appendix), a €20/tCO_2 carbon tax translates in an excise tax of c€4.66/litre.

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Appendix

Table A1 – Average fuel consumer prices, 2011

	Home fuels			Motor fuels	
Month	Electricity €/KWh	Gas €/m^3	Diesel €/litre	Petrol €/litre	Diesel €/litre
1	0.1557	0.7500	1.27	1.45	1.32
2			1.29	1.46	1.35
3			1.36	1.52	1.41
4	0.1618	0.7652	1.37	1.54	1.44
5			1.34	1.54	1.42
6			1.33	1.52	1.40
7	0.1649	0.7970	1.35	1.57	1.45
8			1.35	1.58	1.46
9			1.36	1.58	1.46
10	0.1649	0.8407	1.37	1.59	1.48
11			1.40	1.59	1.51
12			1.40	1.65	1.63

Source: Electricity and gas prices are from AEEG. Diesel and petrol prices are from the Ministry of Economic Development.

Table A2 – Emission factors, 2011

	Home fuels			Motor fuels	
	Electricity $KgCO_2$/KWh	Gas $KgCO_2/m^3$	Diesel $KgCO_2$/litre	Petrol $KgCO_2$/litre	Diesel $KgCO_2$/litre
Factor	0.38	1.96	2.59	2.33	2.58

Source: Authors' calculations based on ISPRA data (Istituto Superiore per la Protezione e la Ricerca Ambientale).

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