Distributional Impacts of Energy-Efficiency Certificates Vs. Taxes and Standards

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Summary

Energy efficiency commitments, often associated with tradable energy efficiency certificates, dubbed "white certificates", were recently implemented in the United Kingdom and Italy and will soon start in France. Energy suppliers have to fund a given quantity of energy efficiency measures, or to buy "white certificates" from other suppliers who exceed their target. We develop a partial equilibrium model to compare white certificates to other policy instruments for energy efficiency, i.e., taxes and standards. Our conclusions are: First, if white certificates are chosen, each supplier's target should be set as a percentage of the energy they sell during the commitment period rather than in absolute terms, e.g. based on past variables. Indeed the latter solution decreases sharply energy suppliers' profit since they cannot pass the cost of certificate generation on to consumers. Such a system thus risks generating a fierce opposition from these industries. Furthermore, setting individual targets independently of the evolution of market shares seems unfair. At last, this system risks creating a large rebound effect, i.e., a large increase in energy services consumption. Second, compared to taxes and standards, white certificates (with targets in percentage of energy sold) seem particularly interesting to reach a certain level of energy savings while limiting distributional effects, thus to limit oppositions to its implementation. Furthermore, they generate less rebound effect than standards and seem more able than taxes to mobilise a part of the no regret potential. However if targets are too weak there is a real risk that white certificates systems fund mostly business-as-usual energy efficiency activities, thus having little impact while delaying the implementation of other policy instruments.

Keywords: White certificate, Energy efficiency certificate, Energy savings, Energy efficiency, Standard, Tax, Rebound effect, No-regret potential

JEL Classification: Q38, Q48, Q58

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Introduction

Energy efficiency and energy savings, which had somewhat dropped from the political agenda following the counter-oil shock of the late 1980's, have recently raised more attention, due in particular to the threat of climate change and to security of supply concerns. Meanwhile, the end of state monopolies in the electricity and gas sectors has lead to design new policy instruments to save energy.

In particular, energy efficiency certificates, dubbed "white certificates", were recently implemented in the United Kingdom (UK Ofgem, 2005; Sykes, 2005) and Italy (Pagliano et al., 2003; Pavan, 2005), and will soon start in France (Moisan, 2004; Dupuis, 2005). Abstracting from various differences among these systems, they may be schematically described as follows. Energy suppliers have to save a given quantity of energy, or, if they are short of their target, to buy "white certificates" from other suppliers. Vice versa, suppliers who have funded more measures than their objective are allowed to sell such white certificates to those who are short of their target. In general, to be taken into account, energy savings have to take place in energy consumers' dwellings or plants, not in energy suppliers' facilities. In practice, suppliers typically fund energy savings in their own customers' dwellings, or contract with appliance retailers who increase their sales of energy-efficient goods in exchange for a funding from the energy supplier.

In the UK, the first such system, labelled the "Energy Efficiency Commitment" (EEC), required suppliers to save 62 TWh of energy in three years, from 1st April 2002 to 31 March 2005. The aggregate goal was largely exceeded since 86.8 TWh were achieved over the three years (UK Ofgem, 2005)[1]. 56% of the reported savings came from thermal insulation programs, 24% from more efficient lighting, 11% from more efficient appliances and 9% from better heating systems. Twelve suppliers groups were set a target under the EEC. Among them, two did not meet their target, generating a shortfall of nearly 1 TWh. Since these companies had ceased energy trading, no penalty was imposed on them because it would have served no practical purpose. Although committed suppliers were allowed to trade commitments or energy efficiency activities, no such trade occurred.

At least half of the target had to be achieved in the "Priority group", defined as those households receiving certain income related benefits and tax credits. This requirement was fulfilled.

[1] Note that this figure is over the lifetime of the equipements funded, not only over the 3-year commitment period. Furthermore, it includes some business-as-usual energy efficiency activities and neglects the "rebound" effect (see below). The real effect of the system on energy consumption may thus be much lower.

The energy efficiency commitment has been extended for the next three years, with a twice more ambitious target (130 TWh over the three years). Suppliers who exceeded their target in the 2002-2005 period are allowed to bank these energy efficiency measures for the 2005-2008 period. This was indeed the reason for the overachievement of the target: as in the U.S. SO_2 cap-and-trade programme, emitters used the banking provision to ease the transition between the first and the second (more ambitious) commitment period (Ellerman and Montero, 2002).

In the present paper, we do not describe these national systems in more details (for this, see the above references, Guardiola Molla et al., 2004, Finon, 2005, or Mairet, 2005), nor analyse how white certificates markets would function (see Langniss and Praetorius, 2006). Instead, we compare white certificates to other policy instruments for energy efficiency, i.e., taxes and standards. On this purpose, we develop a simple partial equilibrium model representing the markets for three commodities: energy, energy-saving goods or services and white certificates.

Although this simple model cannot address all the issues raised by the choice between white certificates and other policy instruments, it is able to assess their contrasted distributive consequences. Indeed, the distributional impacts of policies clearly are highly relevant to social welfare, and such impacts often critically influence political feasibility. In particular, following Olson (1965), it is generally believed that a policy is less likely to be accepted if it concentrates the compliance cost on a small number of actors and disperse the benefits on a large population, and vice-versa. The model also allows to compare white certificates, taxes and standards as regards the rebound effect, i.e., the fact that if the marginal cost of an energy service (e.g., transportation) decreases, its consumption level increases.

We provide two major conclusions. First, if a white certificate system is to be implemented, a generally neglected but important issue is whether the energy-efficiency target imposed to every energy supplier is in proportion of the current quantity of energy sold by this firm or whether this target is disconnected from the firm's current and future decisions. We argue for the former option, which reduces the distributive impact of the policy and the rebound effect.

The second conclusion is about the comparison of white certificates with taxes and standards. We conclude that a white certificates system with targets expressed as a percentage of energy sold is particularly interesting to reach a certain level of energy savings while limiting distributional effects and thus presumably the oppositions to its implementation. Furthermore, it generates less rebound effect than standards and seems more able than taxes to mobilise a part of the no regret potential. Although the robustness of these last two conclusions would need to be checked in more detailed models, it seems that properly designed, a white certificates system is an interesting policy instrument for saving energy.

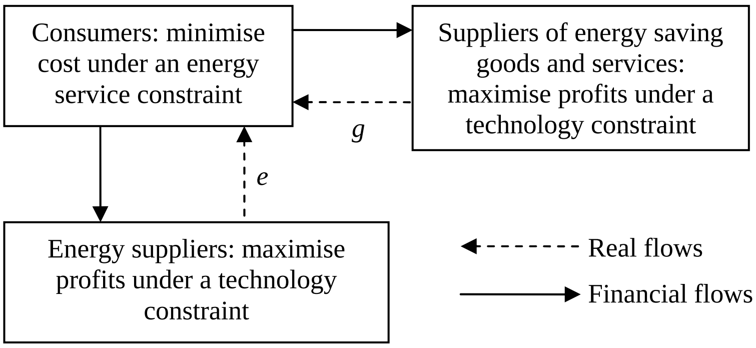
The paper is organised as follows. After introducing the model and the policy instruments (section 1), we present its results (section 2) and then discuss some differences among these instruments that are not directly addressed in the model (section 3). An appendix lists the notations.

1. The model and the five policy instruments

1.1. The model in business-as-usual (i.e., no energy-efficiency policy)

In this very simple partial equilibrium model (cf. figure 1 below), energy consumers (who may be firms or households) buy energy (labelled *e*) and energy-saving goods or services (labelled *g* for "green") to generate a certain level of energy service *ES*. Examples of energy services are heat, light or transportation. *ES* thus represents a certain number of kilometres travelled at a certain speed, comfort and reliability, the heating of a dwelling at a certain temperature, etc. Examples of goods and services represented by *g* are thermal insulation panels, energy-saving devices that make a fridge-freezer more energy-efficient, and so on.

Figure 1. Structure of the model in business-as-usual



We assume that economic agents (in particular energy suppliers and consumers) are perfectly rational and that information is perfect. As a consequence, the model rules out the so-called "no-regret potential" or "energy-efficiency gap" (Jaffe and Stavins, 1994; Sorrel et al., 2004). Although this phenomenon may be seen as one of the main reasons from implementing energy-efficiency policies, various economic mechanisms may explain it and no theoretical model can tackle all these mechanisms. Hence, choosing a model featuring one of the economic mechanisms behind the energy-efficiency gap appears certainly desirable, but only as a second step, once results from a more canonical model with perfect rationality and information are available.

The two goods *e* and *g* are combined in a Cobb-Douglas production function. Consumers choose the combination of *e* and *g* that minimises their cost subject to the constraint that energy service reaches an exogenous level. Formally:

$$\underset{e,g}{Min} \quad P_e.e + P_g.g \tag{1}$$

s.t.: $g^{\alpha} e^{1-\alpha} \geq ES$, $e \geq 0$ and $g \geq 0$

where $\alpha \in (0,1)$ is the budget share of *g*, P_g and P_e are the two goods' prices.

First-order conditions lead to good demands:

$$g_d = \left(\frac{\alpha}{1-\alpha} . \frac{P_e}{P_g} \right)^{1-\alpha} ES \tag{2}$$

$$e_d = \left(\frac{\alpha}{1-\alpha} . \frac{P_e}{P_g} \right)^{-\alpha} ES \tag{3}$$

Each good demand is thus decreasing with its own price and increasing with the other good's price.

The consumer price-index for the energy service is of the standard form for a Cobb-Douglas function (Wilcoxen, 2000):

$$P = \left(\frac{P_e}{\alpha} \right)^{\alpha} \left(\frac{P_g}{1-\alpha} \right)^{1-\alpha} \tag{4}$$

Energy suppliers maximise their profit under perfect competition and produce under linearly decreasing returns[2]. Note that we assume in particular that public authorities do not intervene in energy price setting. Formally, the representative energy supplier program is:

$$\underset{e}{Max} \quad \pi_e = P_e.e - \left(\gamma.e + \frac{\delta}{2} e^2 \right) \tag{5}$$

where $\gamma, \delta > 0$.

The first order condition leads to energy supply, which we assume strictly positive:

$$e_s = \frac{P_e - \gamma}{\delta} \tag{6}$$

Energy supply is thus increasing with the energy price, which is due to the assumption of decreasing returns.

[2] Aggregate decreasing returns are justified by the limited availability of some relatively cheap energy sources, e.g., sites suited to hydropower.

Energy-saving goods and services suppliers maximise their profit under perfect competition and produce under linearly decreasing returns[3]. Formally, the representative supplier program is:

$$\underset{g}{Max} \quad \pi_g = P_g.g - \left(\lambda.g + \frac{\mu}{2} g^2 \right) \tag{7}$$

where $\lambda, \mu > 0$.

The first order condition leads to the supply function, which we assume strictly positive:

$$g_s = \frac{P_g - \lambda}{\mu} \tag{8}$$

The supply of g is increasing with its price, which is also due to the assumption of decreasing returns.

We then numerically solve supply and demand equations (2), (3), (6) and (8), letting e exogenous and modifying some of the above equations as described below, it order to model five policy instruments: two types of white certificates, two types of taxes and one type of standards. We are thus able to compare the outcomes of these policy instruments for a given level of energy savings. We implicitly assume that an excessive energy use entails external costs (air pollution, climate change, threats to security of supply…), justifying an energy-saving policy, but we do not model this part of the issue. In other words, we set a cost-efficiency framework, not a cost-benefit one.

Note that without loss of generality, we normalise the number of firms and consumers to one in order to simplify the notations, but we assume that the real number is large enough for them to be price-takers on all markets.

1.2. White certificates with a target as a percentage of energy sold ($WC_{\%}$)

Under this policy instrument, energy suppliers have to generate a given amount of energy efficiency measures, in a quantity $c.e$ proportional to the quantity of energy they sell, e. To fulfil this obligation, we assume that they can only subsidise energy-efficiency goods and services. For each unit of g they subsidise, they get k white certificates. We assume that firms comply with this obligation, so the quantity of white certificates equals the aggregate target. Since we model only one type of energy-efficiency goods and services, it is impossible to distinguish business-

[3] Aggregate decreasing returns are justified by the fact that among the number of energy efficiency options available, the cheapest are tapped first.

as-usual purchase of *g* from additional energy efficiency measures. We thus assume that every sale of *g* is subsidised[4].

A new equation appears, the energy-efficiency constraint put by public authorities on energy suppliers:

$$c.e \leq k.g \qquad (9_{\,WC\%})$$

We assume that this constraint is binding. Otherwise, the price of white certificates would drop to zero and the policy would have no effect at all.

Consumers of the energy service are not directly affected, hence the first four equations do not change.

Equations (5) to (8) are modified as below:

$$\underset{e}{Max} \quad \pi_e = \left(P_e - P_c.c\right)e - \left(\gamma.e + \frac{\delta}{2}e^2\right) \qquad (5_{\,WC\%})$$

$$e_s = \frac{P_e - P_c.c - \gamma}{\delta} \qquad (6_{\,WC\%})$$

$$\underset{g}{Max} \quad \pi_g = \left(P_g + P_c.k\right)g - \left(\lambda.g + \frac{\mu}{2}g^2\right) \qquad (7_{\,WC\%})$$

$$g_s = \frac{P_g + P_c.k - \lambda}{\mu} \qquad (8_{\,WC\%})$$

where P_c is the price of a white certificate.

1.3. White certificates with an absolute target (WC_A)

The only difference with $WC_{\%}$ is that energy suppliers now have to deliver white certificates in a fixed quantity *c*. We will see in the "results" section that this distinction has important consequences. It does not matter whether the *aggregate* goal is expressed in absolute or relative terms; what is important is that each producer's target is defined independently of this producer's current and future decisions[5]. The target may for instance be proportional to the historical market share of each producer.

The equilibrium on the white certificates market becomes:

$$C = k.g \qquad (9_{\,WCA})$$

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[4] In the real world, such a distinction would be very costly. Accordingly, the regulator of the UK scheme recognises that "the target included business as usual energy efficiency activity" (UK Ofgem, 2005, p. 5).

[5] Note that in the UK, targets are a function of the number of customers, a somewhat intermediary case which would require a more complex model to be explicitly analysed; cf. UK Ofgem (2005).

where C is the energy producer's target.

Here again, consumers of the energy service are not directly affected, hence the first four equations do not change.

Equations (5) to (8) are modified as follow:

$$\underset{e}{Max} \quad \pi_e = P_e.e - P_c.C - \left(\gamma.e + \frac{\delta}{2} e^2 \right) \qquad (5_{\text{WCA}})$$

$$e_s = \frac{P_e - \gamma}{\delta} \qquad (6_{\text{WCA}})$$

$$\underset{g}{Max} \quad \pi_g = \left(P_g + P_c.k \right) g - \left(\lambda.g + \frac{\mu}{2} g^2 \right) \qquad (7_{\text{WCA}})$$

$$g_s = \frac{P_g + P_c.k - \lambda}{\mu} \qquad (8_{\text{WCA}})$$

1.4. Tax rebated lump-sum to consumers (T_C)[6]

Under this instrument, energy produced is taxed at a rate t and receipts from the tax are given lump-sum to energy consumers.

Compared to the initial model, only equations (5) and (6) are modified as below:

$$\underset{e}{Max} \quad \pi_e = \left(P_e - t \right) e - \left(\gamma.e + \frac{\delta}{2} e^2 \right) \qquad (5_{\text{TC}})$$

$$e_s = \frac{P_e - t - \gamma}{\delta} \qquad (6_{\text{TC}})$$

Where t is the tax rate per energy unit. Consumers get a lumps-sum subsidy of $t.e$. The subsidy does not affect consumers' behaviour: since we assume that the level of energy service is exogenous, there is no revenue effect.

1.5. Tax rebated lump-sum to energy suppliers (T_E)[7]

The only difference with the previous instrument is that the receipts from the tax are now rebated (lump-sum) to energy suppliers and not to consumers. Compared to the initial model, only equations (5) an (6) are modified, in a way which does not affect firms' behaviour:

[6] Since we do not model uncertainty on costs, this instrument is equivalent to a tradable permits scheme imposed to energy suppliers, with permits auctioned and receipts transferred to consumers. However, in general, tradable permits cover noxious emissions, not energy sold.

[7] In our model, this would be equivalent to a tradable permits scheme with permits grandfathered, i.e., distributed for free to energy suppliers, with the same caveat as in the last footnote.

$$\underset{e}{Max} \quad \pi_e = \left(P_e - t\right)e - \left(\gamma.e + \frac{\delta}{2}e^2\right) + GF \qquad (5_{\ TE})$$

$$e_s = \frac{P_e - t - \gamma}{\delta} \qquad (6_{\ TE})$$

where *GF* (for grandfathering) is the lump-sum subsidy received by each energy supplier. A last equation describes the public budget balance:

$$t.e = GF \qquad (9_{\ TE})$$

1.6. Standards (S)

Consumers still minimise their cost according to equation (1) but now subject to a new constraint: $g \geq g_{\min}$, which we assume to be binding. This is a classical and straightforward way of modelling energy efficiency standards; cf. Wirl (1989). In other words, they have to purchase a minimum quantity of energy-efficiency goods and services. Compared to the initial model, the consumers' programme is now:

$$\underset{e}{Min} \quad P_e.e + P_g.g_{\min} \qquad (1_{\ S})$$

s.t.: ${g_{\min}}^{\alpha} e^{1-\alpha} \geq ES$ and $e \geq 0$.

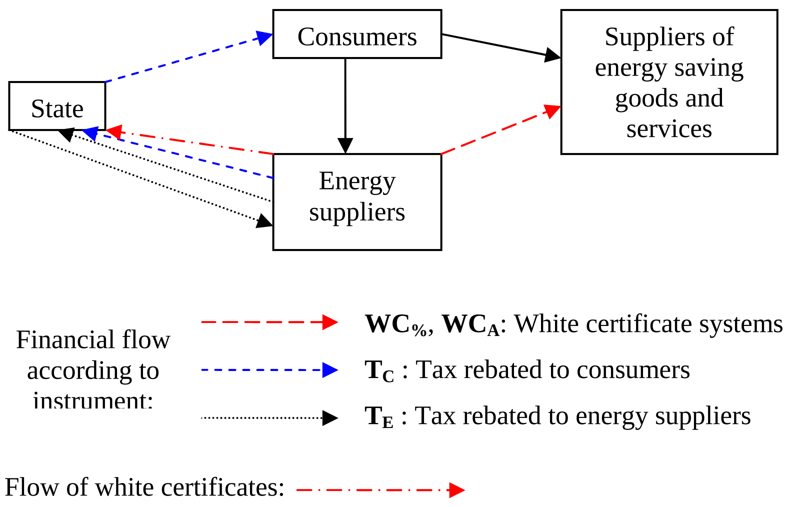
Equations 2 and 3 become:

$$g_d = g_{\min} \qquad (2_{\ S})$$

$$e_d = {g_{\min}}^{-\frac{\alpha}{1-\alpha}} SE^{\frac{1}{1-\alpha}} \qquad (3_{\ S})$$

Figure 2 below displays the financial flows for each policy instruments. Flows arising whatever the instrument (and in business-as-usual) are in plain lines, others are in dotted lines.

Figure 2. Financial flows in the model



2. Results

For each instrument, we have solved the model for a given level of energy consumption. Figures 3 to 5 display the results and a table below summarises them.

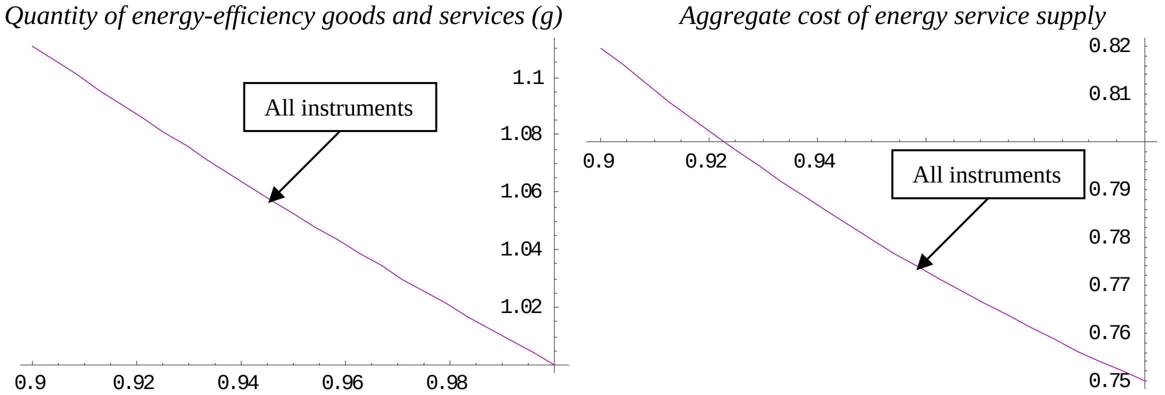
Impact of the five policy instruments relative to business-as-usual, for a given level of energy saving

	$WC_{\%}$	WC_A	T_C	T_E	S
Energy price	+	–	++	++	–
g price	–	– –	+	+	+
White certificates price	+	++	NA	NA	NA
Profit for energy suppliers	–	– –	–	+	–
Profit for *g* producers	+	+	+	+	+
Cost for consumers	+	–	+	++	+
Price index of energy service	+	–	++	++	=

$WC_{\%}$: white certificates with a target in percentage of energy supply
WC_A: white certificates with an absolute target
T_C: tax, receipts rebated lump-sum to energy consumers
T_E: tax, receipts rebated lump-sum to energy suppliers
S: standards
NA: non applicable

In the figures 3 to 5, the x-axis represents the level of energy consumption, from 0.9 (a 10% cut) to 1 (BaU level). As indicated in figure 3, it turns out that every instrument yields the same aggregate real evolutions: quantity of *e* (by construction), quantity of *g* and aggregate cost of energy service supply, i.e., cost to consumers minus profits of both goods' producers.

Figure 3. Illustrative quantitative results for real variables



x-axis: level of energy consumption, from 0.9 (a 10% cut) to 1 (Business-as-usual level)

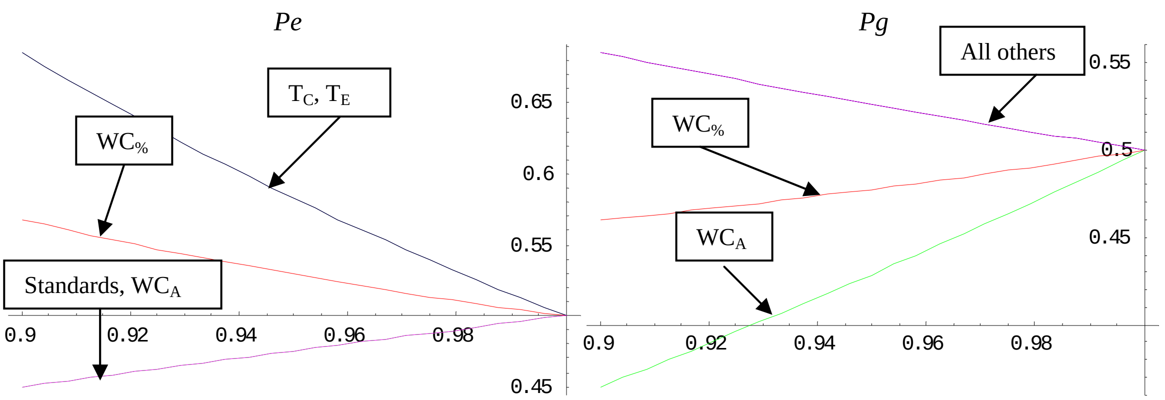
In all graphs, we took $\lambda = \gamma = 0,\ \alpha = \mu = \delta = 0.5,\ ES = 1$.

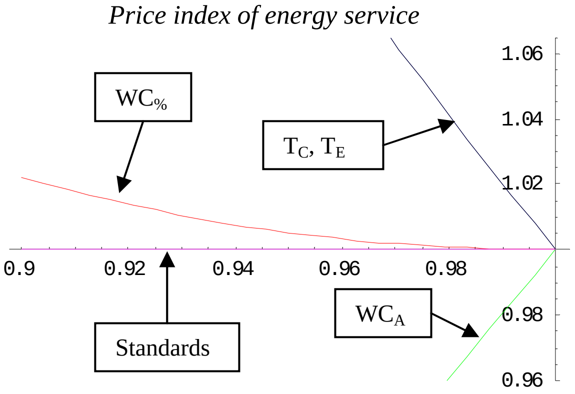
Of course, this equivalence would not prevail in a more sophisticated model, and below we provide an informal discussion of some differences that would arise. However distributive impacts differ sharply, which casts some light on the political feasibility of the policy instruments.

2.1. Prices

As indicated by figure 4 below, the evolution of the energy price is much contrasted: it goes down under standards and white certificates with absolute targets, and up with the other three instruments. Among the latter, it raises less under white certificates with a percentage target than under the two taxes.

Figure 4. Illustrative quantitative results for prices





x-axis: level of energy consumption, from 0.9 (a 10% cut) to 1 (Business-as-usual level)

In all graphs, we took $\lambda = \gamma = 0,\ \alpha = \mu = \delta = 0.5,\ ES = 1$.

These evolutions may be explained as follows. Under all instruments, the decrease in energy consumption makes the energy price go downward, since the energy supply curve is upward-slopping. Under standards and absolute white certificates, this is the only influence on energy price. However, under both taxes, the energy price rises since suppliers pass the tax on to consumers. It is the same under white certificates with percentage targets: since suppliers must generate more certificates if they increase their production, the certificates' cost is a part of their marginal cost, hence of energy price. However the rise in energy price is lower under $WC_{\%}$ than under the taxes. Indeed, under the former, energy saving comes from two channels: the decrease in the price of *g* and the rise in the price of *e*, so for a given level of energy saving, the evolution of each of these prices may be lower than if only one channel was used.

The price of energy-saving goods and services to consumers goes down under white certificates since they are subsidised. This drop is stronger if the target is absolute than if it is in percentage because, as we have just seen, in the latter case a part of the decrease in energy consumption stems from the rise in energy price. The price of *g* rises under the three other instruments because the supply curve is assumed upward-slopping and demand rises.

The evolution of the price index of energy service (equation 4) is also much contrasted. It raises a lot under the taxes, raises also, but less, under $WC_{\%}$, stands still under standards and decreases under WC_A. This feature has important consequences for the rebound effect, as we shall see below.

Comparing both white certificates systems, the certificates price is higher with an absolute target since once again a part of the decrease in energy consumption comes from the rise in energy price.

2.2. Distributional consequences

As indicated by figure 5, compared to the business-as-usual, energy suppliers' profit drops in the same proportion for all but two instruments:

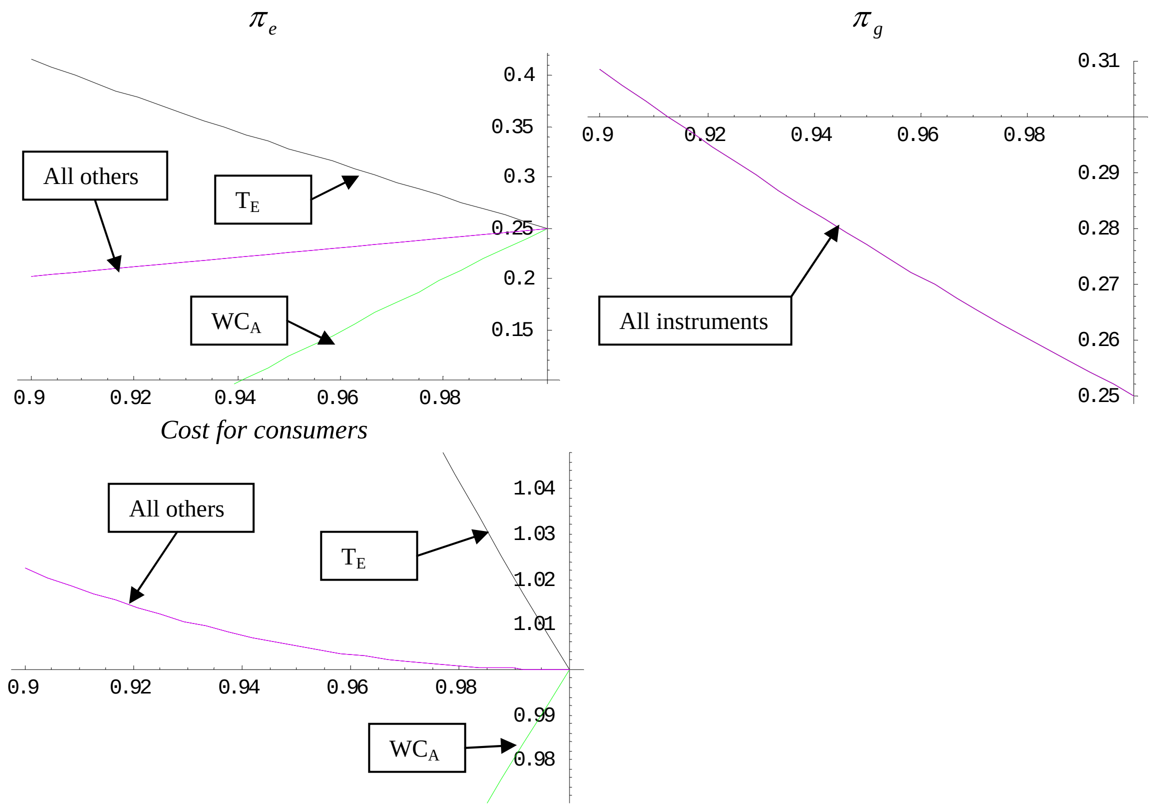
- It rises under T_E since the energy price increases despite energy suppliers being subsidised: since this subsidy is lump-sum, it does not influence their pricing behaviour, based on marginal cost. Energy suppliers thus benefit from a windfall profit under this instrument;
- It drops more under absolute white certificates since energy suppliers are unable to raise their price although they have to pay to generate white certificates.

Energy-saving goods and service producers' profit rises in the same proportion under all instruments.

The cost for consumers, that is, the cost of buying the energy service components minus the subsidy (under T_C), raises in the same proportion, except under two instruments:

- It rises more under T_E since the energy price raises without any compensation for consumers;
- It drops with WC_A since the price of g goes down while energy suppliers are unable to pass the certificates' cost on to consumer.

Figure 5. Illustrative quantitative results for distributional consequences



x-axis: level of energy consumption, from 0.9 (a 10% cut) to 1 (Business-as-usual level)

In all graphs, we took $\lambda = \gamma = 0$, $\alpha = \mu = \delta = 0.5$, $ES = 1$.

These contrasted consequences cast some light on the equity and political acceptability impact of our policy instruments. Although forecasting the possibility for a proposal to survive the policy process is a very difficult task, one influential analysis was developed by Olson (1965), who argued that the degree of political mobilisation of interest groups depends on the concentration of the distributional impact. Concentrated potential costs alleviate free-rider problems in lobbying efforts and thus may result in significant contributions of time and other resources to become engaged in the political process. If costs are sufficiently concentrated relative to benefits, therefore, the agents who would face these costs would exert greater influence on the political process than those who would enjoy the widely dispersed benefits and thus face more serious free-rider problems (Bovenberg et al., 2005). This explains in particular why in existing systems tradable permits tend to be distributed freely rather than auctioned even though the general equilibrium cost of auctioning is lower (Boemare and Quirion, 2002).

To sum up, a policy is less likely to be accepted if it concentrates the compliance cost on a small number of actors. How do our five instruments perform in this respect?

First, white certificates with absolute targets decrease sharply energy suppliers' profit since it is then impossible to pass the cost of certificate generation on to consumers.[8] Such a system thus risks generating a fierce opposition from these industries. Furthermore, setting individual targets independently of the evolution of market shares seems particularly unfair.

On the opposite, the tax rebated lump-sum to energy suppliers raises their profit, since they may pass a part of the tax's cost on to consumers. They benefit from a "windfall profit", as under a grandfathered permits system (Bovenberg et al., 2005). However this instrument is the costliest to consumers, who will oppose it if they are organised enough for that. This fear of windfall profits for energy suppliers and cost surge for large electricity industrial consumers is very acute in the debate on the European Union CO_2 trading directive, opposed to by some powerful electricity-consuming industries such as the German chemical industry.

The other three instruments ($WC_{\%}$, T_C and standards) have equivalent distributional impacts in our model. However this equivalence requires that tax receipts are effectively rebated to consumers, an assumption often considered unlikely by most industry interest groups, reducing the political feasibility of this instrument. On the other hand, tax receipts may serve to cut the most distorsive or the most unpopular pre-existing taxes, increasing the political feasibility of this instrument. It is difficult to draw general conclusions, except that the roles of interest groups and ideology are determinants.

At last, white certificates with a percentage target present a further advantage as regards equity and acceptability: since targets are set for energy suppliers who benefit from a commercial direct link to consumers, they may implement energy saving activities themselves and thus keep a part of the profit which, in our model, benefits to producers of *g*. Hence in the real world energy producers might be able to win, as energy-efficiency providers, at least a part of the profit they would loose in their core business. This would further reduce distributional consequences, thus facilitating political acceptability.

All in all, a system of white certificates seems particularly interesting to reach a certain level of energy savings while limiting distributional effects, thus to limit oppositions to its implementation. To caveats are in order:

- If targets are too weak, white certificates systems have no effect: they just fund business-as-usual energy efficiency activities and the certificates price drops to zero;

[8] We stress that this conclusion would not necessarily hold if we dropped our assumptions of perfect competition and of no public intervention on the energy market.

- Some simplifying assumptions in the model prevent from analysing important differences among these instruments. In the next section we discuss some of these issues less formaly.

3. Issues not included in the model

3.1. The rebound effect

The rebound effect refers to the fact that if the marginal cost of an energy service decreases, its consumption level increases[9]. For example, following a higher mileage (i.e., a lower fuel consumption per kilometre), traffic increases since the marginal "transportation" energy service becomes cheaper. This is a well-known negative side-effect from standards, demand-side management programmes and incentives to R&D, which leads many economists to reject these measures in favour of energy taxes.

Although in our model the level of energy service is exogenous, which prevents us from fully analysing the rebound effect, the price of energy service P as well as the price of energy P_e cast some light on this issue.

P represents for example the cost of buying *and* using a new car or a new fridge-freezer, to insulate and warm a new room, and so on. From figure 2, we see that P increases sharply under taxes, increases but less under $WC_{\%}$, stands still under standards and decreases under WC_A.

P_e approximates the marginal cost of using more a car (abstracting for wearing, risks of accident and so on), of turning up the heat in existing heated rooms, etc. It increases sharply under taxes, increases but less under $WC_{\%}$ and decreases under standards and WC_A.

All in all, WC_A is thus likely to generate a large rebound effect, which would reduce energy savings and increase the aggregate cost for a given energy saving. This consideration adds up to equity and political acceptability conclusions mentioned above to prefer relative over absolute targets for white certificates.

Another interesting point is that as regards the rebound effect, $WC_{\%}$ seems less prone to the rebound effect than standards but more than taxes. However quantifying the rebound effect that may stem from these instruments would require a much more complex model.

3.2. The "energy-efficiency gap"

Apart from environmental and security of supply concerns, another rationale to save energy is the "energy-efficiency gap" or "no-regret potential" identified by many engineering studies. This

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[9] See the special issue of *Energy Policy*, June 2000.

refers to the fact that many opportunities to save energy are not implemented by consumers although the decrease in fuel cost would outweigh the cost of the energy efficiency investment according to standard cost-benefit analysis. This raises some doubts on the efficiency of energy taxes: if consumers take little account of energy price in their behaviour, raising this price is unlikely to cut energy consumption sharply. On the opposite, standards, if strictly implemented, may be economically efficient by forcing consumers to implement energy-efficiency measures that are financially profitable but bypassed in business-as-usual.

Would white certificates help mobilising the energy-efficiency gap? The answer obviously depends on what explains this gap. Many explanations have been put forward (cf. Jaffe and Stavins, 1994, and Sorrell et al., 2004). We will not restate them here but simply stress that white certificates may help alleviating some (but not all) of them. Indeed several explanations of the energy-efficiency gap point that some consumers attach more importance to investment costs than to energy costs, for various reasons: limited access to credit due to asymmetric information by lenders on the credit market, split incentives to save energy, e.g., in collective housing or commercial centres, rigid separation between investment and operating budget in organisations…

By reducing the cost of energy-efficient capital goods, white certificates may thus help mobilising a part of the energy-efficiency gap more easily than taxes. However this intuition would have to be checked in a formal model featuring some factors which explain the energy-efficiency gap, including those mentioned above. We leave this for future research.

Conclusion

In the present paper, we compare white certificates to other policy instruments for energy efficiency, i.e., taxes and standards. In this purpose, we develop a simple partial equilibrium model representing the markets for three commodities: energy, energy-saving goods or services and white certificates. Although this simple model cannot address all the issues raised by the choice between white certificates and other policy instruments, it is able to assess their contrasted distributive consequences. Indeed, the distributional impacts of policies clearly are highly relevant to social welfare, and such impacts often critically influence political feasibility. Our conclusions are the following.

First, if energy-efficiency (or "white") certificates are chosen, every supplier's target should be set as a percentage of its current output rather than in absolute terms, e.g. based on past variables. Indeed the latter solution decreases sharply energy suppliers' profit since they cannot pass the cost of certificate generation on to consumers. Such a system thus risks generating a fierce opposition from these industries. Furthermore, setting individual targets independently of the evolution of market shares seems particularly unfair. At last, this system risks creating a large rebound effect, i.e., a large increase in energy services consumption.

Second, a white certificates system with targets expressed as a percentage of energy sold seems particularly interesting to reach a certain level of energy savings while limiting distributional effects, thus also limiting oppositions to its implementation. Furthermore, it generates less rebound effect than standards and seems more able than taxes to mobilise a part of the no regret potential. Although the robustness of these last two conclusions would need to be checked in more detailed models, it seems that properly designed, white certificates systems are an interesting policy instrument for saving energy. However if targets are too weak white certificates systems will have no effect: they will just fund business-as-usual energy efficiency activities. There is thus a real risk that a white certificates system leads to little impact while delaying the implementation of other, possibly more efficient policy instruments.

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Appendix: list of notations

Notation	Domain	Signification	instrument
e	> 0	Quantity of energy	All
g	> 0	Quantity of energy-saving goods and services	"
P_e	> 0	Price of energy	"
P_g	> 0	Price of the energy-saving goods and services	"
ES	> 0	Level of energy service	"
α	$\in (0,1)$	Share of *g* in consumers' budget	"
P	> 0	Price index	"
γ	≥ 0	Intercept of energy suppliers' marginal production cost curve	"
δ	≥ 0	Slope of energy suppliers' marginal production cost curve	"
λ	≥ 0	Intercept of *g* suppliers' production cost curve	"
μ	≥ 0	Slope of *g* suppliers' marginal production cost curve	"
c	≥ 0	Energy savings target for each unit of energy sold	$WC_{\%}$
C	≥ 0	Energy savings target for each supplier	WC_A
k	≥ 0	Number of certificates generated per unit of *g* subsidized	$WC_{\%}$,WC_A
P_c	≥ 0	Price of white certificates	$WC_{\%}$,WC_A
t	≥ 0	Tax rate	T_C,T_E
GF	≥ 0	Lump-sum subsidy to energy suppliers	T_E
g_{min}	≥ 0	Minimum quantity of *g* consumers have to purchase	S

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