European experiences with white certificate obligations: A critical review of existing evaluations

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Pre-print, *Economics of Energy & Environmental Policy*

Abstract

White certificate obligations impose energy savings targets on energy companies and allow them to trade energy savings certificates. They can be seen as a means of internalizing energy-use externalities and addressing energy efficiency market failures. This paper reviews existing evaluations of experiences with white certificate obligations in Great Britain, Italy and France. *Ex ante* microeconomic analysis find that the obligation is best modelled as a hybrid subsidy-tax instrument, whereby energy companies subsidize energy efficiency and pass-through the subsidy cost onto energy prices. *Ex post* static efficiency assessments find largely positive benefit-cost balances, with national differences reflecting heterogeneity in technical potentials. Compliance involved little trading between obligated parties. Whether the cost borne by obligated parties was recovered through increased energy revenue could not be ascertained. *Ex post* dynamic efficiency assessments find that in addition to addressing liquidity constraints through subsidies, white certificate obligations seem to have addressed informational and organisational market failures. Confidence in these conclusions is limited by the fact that no econometric analysis was performed. Yet the lack of publicly available data, a counterpart to the rationale of the instrument of harnessing private financing, makes any empirical evaluation of white certificate obligations challenging.

Keywords

White certificate obligation, energy savings, energy efficiency gap, static efficiency, dynamic efficiency

Executive summary

Energy saving obligations and credits, better known as 'white certificate obligations', have been introduced in Great Britain in 2002, in Italy in 2005 and in France in 2006. They oblige energy companies to achieve certified amounts of energy savings by inducing their customers to adopt energy efficient technologies. Companies that fall short of their pre-assigned target are allowed to buy certificates from others that exceeded theirs or from qualified third parties, such as energy service companies.

This policy is advocated as a market-based instrument for internalizing externalities associated with energy use. Proponents of the instrument frequently put forward an additional argument for its implementation: To meet their energy savings targets, energy companies are forced to identify and address some of the market failures that occur in the markets for energy efficiency.

The flexibility offered by the instrument involves a variety of potential delivery routes. This poses several challenges to the economic understanding of the instrument, as well as to its empirical evaluation.

First, to keep measurement and verification costs reasonable, energy savings are typically certified through standardized *ex ante* calculations. These calculations assume conventional installation and utilization of energy efficient technologies, two elements that in reality carry much heterogeneity. In this context, there is little chance that standardized calculations reflect real energy savings, so the effectiveness of the instrument regarding carbon dioxide emission reductions is difficult to assess.

Second, white certificates obligations force energy companies to offer solutions to energy efficiency market failures: financing provisions (subsidies, borrowing facilities) to address liquidity constraints, energy audits to address information gaps or performance guarantees to address principal-agent problems. This raises empirical issues: Given the variety of services energy companies may offer to meet their obligation, how to delineate the cost they bear? This problem further complicates cost-effectiveness assessment of the instrument.

Third, an energy-saving obligation placed on energy companies is a peculiar constraint: Saving energy directly conflicts with the business goal of selling energy. Yet at least in theory, the British, French and Italian energy markets have been liberalized according to rules set out by European directives. In this context, energy companies can overcome the above-mentioned conflict by passing-through the cost of the obligation onto their energy prices. However, whether the identified change in energy revenue (if any) is commensurate with the cost of the obligation is empirically hard to test.

In this paper, we review existing evaluations of European experiences with white certificate obligations and investigate how these analyses have coped with the evaluation challenges discussed above.

We identified three evaluation sequences, each driven by a specific question. A first phase occurred at the time when the national obligations were implemented (2004-2009). As very few *ex post* data were available and the theoretical underpinnings of the instrument were still not well understood, the analysis focused on *ex ante* microeconomic modelling. A hybrid subsidy-tax view of the instrument emerged, according to which energy producers offer subsidies to consumers for the purchase of energy efficient durables and pass through the subsidy cost onto energy prices. This view raises some issues that have not been further investigated: What are the distributional consequences of the instrument if the subsidy is granted to some consumers while being paid by all of them through higher energy prices? Beyond price-signals, does the instrument address information gaps and other market failures?

A second evaluation phase occurred after completion of the first periods of the obligations (2008-2012). As data became available, analysis focused on assessing the static efficiency of national obligations, that is, their cost-effectiveness and benefit-cost performance. A substantial effort was put into estimating the costs borne by obligated parties, taking effectiveness as given by standardized calculations. A finding robust to all countries was that energy efficiency measures were delivered cost-effectively, yet consisted mainly in low-hanging fruits. Certificate trading between obligated parties was very limited. The analysis did not offer convincing results about the degree of additionnality, the reliability of standardized calculations and the specific effect of the instrument within a broader policy portfolio.

A third evaluation phase started recently with consumer and stakeholder surveys conducted by public bodies. Attention is shifted from grossly quantifying the costs of the obligations to more finely assessing their dynamic effect on consumer decision-making and industrial organizations. While these works reveal that subsidies are key to trigger energy efficiency investment, they also underline information provisions as an important factor. Organizational change occurred differently in all countries and seemed to depend strongly on specific institutional environments. Though informative, the relevance of these surveys is limited by issues such as the absence of control groups, so that no serious conclusion can be drawn about the additionality of white certificate obligations.

The main lesson from this critical review is that beyond country-specific outcomes, existing evaluations find benefits of white certificate obligations that largely exceed their costs. The instrument seems to address informational and organisational failures that occur in energy efficiency markets. Yet confidence in these insights is low. As of today, no econometric analysis of any national experience

with white certificate obligation has been conducted. Quantifying the specific effect of the instrument on effective energy savings, on energy efficiency market transformation, and any energy price increase that may result from the obligation is a priority for future research. On the theoretical front, more work is needed to better understand the distributive impacts of the instrument, the type of market failures it can best address, its articulation with overlapping instruments and its political economy implications.

1 Introduction

Energy saving obligations and credits, better known as 'white certificate obligations', have been introduced in Great Britain in 2002, in Italy in 2005 and in France in 2006[1]. They oblige energy companies to achieve certified amounts of energy savings by inducing their customers to adopt energy efficient technologies. Companies that fall short of their pre-assigned target are allowed to buy certificates from others that exceeded theirs or from qualified third parties, such as energy service companies.

This policy is advocated as a market-based instrument for internalizing externalities associated with energy use: Market forces equalize the marginal cost of abatement among participants, which allows an energy savings target (or, equivalently, a carbon dioxide emission reduction target) to be met at minimum aggregate cost. Proponents of the instrument frequently put forward another argument for its implementation: To meet their energy savings targets, energy companies are forced to identify and address some of the market failures that occur in the markets for energy efficiency. These market failures include information asymmetries, credit constraints or organisational inefficiencies. Altogether, they lead to a socially suboptimal level of energy efficiency investment, a phenomenon commonly referred to as the 'energy efficiency gap' (Jaffe and Stavins, 1994).

The flexibility offered by the instrument involves a variety of potential delivery routes. This poses several challenges to the economic understanding of the instrument, as well as to its empirical evaluation.

First, white certificate obligations are one of the few examples of a 'baseline-and-credit' system. Unlike cap-and-trade systems, which have dominated experiences with market-based instruments, baseline-and-credit systems impose a minimum performance, not a maximum ceiling. Certification of a minimum performance involves the definition of a counterfactual baseline, which is fraught with arbitrariness. Moreover, to keep measurement and verification costs reasonable, additional energy savings are typically certified through standardized *ex ante* calculations. These calculations assume conventional installation and utilization of energy efficient technologies, two elements that in reality carry much heterogeneity. In this context, there is little chance that standardized calculations reflect real energy savings, so the effectiveness of the instrument regarding carbon dioxide emission reductions is difficult to assess.

[1] Similar obligations have been introduced without trading provisions in Denmark, Flanders in Belgium and New South Wales in Australia. See Bertoldi and Rezessy (2008) for more detail.

Second, white certificates are commonly viewed as a multifunctional instrument capable of jointly addressing several market failures. This belief is attested by repeated claims found in government documents that white certificate obligations would help turn the energy supplier business model into a broader energy service business model. In this view, the obligation forces energy companies to offer solutions to energy efficiency market failures: financing provisions (subsidies, borrowing facilities) to address liquidity constraints, energy audits to address information gaps or performance guarantees to address principal-agent problems. This raises theoretical issues: If standard microeconomic theory warrants as many instruments as there are market failures (Tinbergen, 1952), can one single instrument address multiple failures? It also raises empirical issues: Given the variety of services energy companies may offer to meet their obligation, how to delineate the cost they bear? This problem further complicates cost-effectiveness assessment of the instrument.

Third, an energy-saving obligation placed on energy companies is a peculiar constraint: Saving energy directly conflicts with the business goal of selling energy. Yet at least in theory, the British, French and Italian energy markets have been liberalized according to rules set out by European directives[2]. In this context, energy companies can overcome the above-mentioned conflict by passing-through the cost of the obligation onto their energy prices. Empirical validation of such a mechanism is challenging, though. The identification of any induced price change is subject to well-known econometric difficulties. In particular, it is hard to disentangle from the effects of discriminatory pricing and time-lags in the transmission of wholesale prices to retail prices. Moreover, in the free-market spirit of the instrument, participants are not required to disclose their cost[3]. The certificate trading price, which is the only cost proxy left, may lack transparency. Therefore, whether the identified change in energy revenue (if any) is commensurate with the cost of the obligation is hard to test.

In this paper, we review existing evaluations of European experiences with white certificate obligations. We examine both national and cross-country evaluations. We focus on articles from peer-reviewed journals and use government reports when they are the only information available. We

[2] Directives of the European Parliament and of the Council of 1996 concerning the internal electricity market (Directive 96/92/EC) and of 1998 concerning the internal gas market (Directive 98/30/EC), complemented by directives of 2003 and 2009 (2003/54/CE, 2003/55/CE, 2009/72/CE, 2009/73/CE).

[3] This comes in contrast with demand-side management (DSM) programs introduced in the U.S. in the 1970s, where cost disclosure was mandatory. For further discussion about the links between white certificate obligations and DSM programs, see Giraudet et al. (2012).

investigate how these analyses have coped with the evaluation challenges discussed above. We draw lessons from the European experiences with white certificate obligations and comment on some persistent knowledge gaps.

We identified three evaluation sequences, each driven by a specific question. A first phase occurred at the time when the national obligations were implemented (2004-2009). As very few *ex post* data were available and the theoretical underpinnings of the instrument were still not well understood, the analysis focused on *ex ante* microeconomic modelling. A hybrid subsidy-tax view of the instrument emerged, according to which energy producers offer subsidies to consumers for the purchase of energy efficient durables and pass through the subsidy cost onto energy prices. This view raises some issues that have not been further investigated: What are the distributional consequences of the instrument if the subsidy is granted to some consumers while being paid by all of them through higher energy prices? Beyond price-signals, does the instrument address information gaps and other market failures?

A second evaluation phase occurred after completion of the first periods of the obligations (2008-2012). As data became available, analysis focused on assessing the static efficiency of national obligations, that is, their cost-effectiveness and benefit-cost performance. A substantial effort was put into estimating the costs borne by obligated parties, taking energy effectiveness as given by standardized calculations. A finding robust to all countries was that energy efficiency measures were delivered cost-effectively, yet consisted mainly in low-hanging fruits. Certificate trading between obligated parties was very limited. The analysis did not offer convincing results about the degree of additionnality, the reliability of standardized calculations and the specific effect of the instrument within a broader energy efficiency policy portfolio.

A third evaluation phase started recently with consumer and stakeholder surveys conducted by public bodies. Attention is shifted from grossly quantifying the costs of the obligations to more finely assessing their dynamic effect on consumer decision-making and industrial organizations. While these works reveal that subsidies are key to trigger energy efficiency investment, they also underline information provisions as an important factor. Organizational change occurred differently in all countries and seemed to depend strongly on specific institutional environments. Though informative, the relevance of these surveys is limited by issues such as the absence of control groups, so that no serious conclusion can be drawn about the additionality of white certificate obligations.

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with white certificate obligation has been conducted. Quantifying the specific effect of the instrument on effective energy savings, on energy efficiency market transformation, and any energy price increase that may result from the obligation is a priority for future research. On the theoretical front, more work is needed to better understand the distributive impacts of the instrument, the type of market failures it can best address, its articulation with overlapping instruments and its political economy implications.

Sections 2 to 4 of this paper detail the three evaluation sequences: *ex ante* microeconomic analyses; *ex post* cost-benefit analyses; *ex post* qualitative surveys. Section 5 draw lessons and discusses persistent knowledge gaps. A comparative description of the different obligation designs can be found in Giraudet and Finon (2011).

2 First evaluation phase: *ex ante* microeconomic analysis

Implementation of white certificate obligations in Great Britain in 2002, in Italy in 2005 and in France in 2006 stimulated some economic research. Before any empirical evaluation was made available, many research papers were published in energy and environmental economics and policy journals[4]. Using various degrees of formalization, they had in common to seek to elucidate the basic mechanisms of the instrument. Several results emerged.

2.1 A hybrid, second-best solution to energy-use externalities

One rationale behind saving energy is to reduce negative externalities associated with energy use. Such externalities include carbon dioxide emissions responsible for global climate change, but also local pollution and energy security issues. The classic first-best solution to these problems is to price the externality (through taxes or tradable quantities) at a rate that reflects its marginal damage.

How do white certificate obligations perform regarding the energy-use externality problem? A set of microeconomic models have attempted to clarify the incentives they offer to save energy, in an idealized context where no other market failures occur. These works build on a hybrid subsidy-tax representation of the instrument: Energy producers are constrained to offer subsidies to consumers for the purchase of energy efficient durables and allowed to pass through the subsidy cost onto energy prices (Bye and Bruvoll, 2008; Giraudet and Quirion, 2008; Oikonomou *et al.*, 2008; Peerels, 2008; Sorrell et al., 2009a). In this view, a white certificate obligation delivers energy savings less cost-effectively than the first-best energy tax, but more cost-effectively than a pure subsidy on energy efficiency yielding the same level of energy savings. In particular, it induces a smaller rebound effect

[4] See for instance the special issue of *Energy Efficiency* published in 2008 (volume 1, issue 4).

than the subsidy, since the increase in the use of energy service induced by the subsidy component is countervailed by a decrease induced by the tax component (Giraudet and Quirion, 2008).

Compared to the first-best energy tax, white certificate obligations induce a lower increase in energy price[5]. This may make them more politically acceptable than the tax, despite a lower economic efficiency. Overall, the price effects of white certificate obligations are asymmetric if the tax is levied on all energy consumers to fund a subsidy granted to only a few, which may raise equity concerns (Sorrell et al., 2009a).

In all countries, white certificate obligations coexist with the E.U CO_2 Emissions Trading System. The latter can be seen as a first-best solution to reduce CO_2 emissions. Standard microeconomic reasoning predicts that the combination of the two instruments will reduce CO_2 emissions less cost-effectively than the stand-alone first-best instrument (the E.U. ETS)[6].

Note that if internalizing energy-use externalities is to be the main justification of white certificate obligations, then the target should be formulated in external damages to abate, not energy savings. As it turns out, this is not everywhere the case: Whereas it is labelled in carbon dioxide emission savings in Great Britain, it is labelled in kilowatt-hours of final energy savings in both Italy and France, with no correction for the carbon content of the fuel saved.

2.2 A solution to the 'energy efficiency gap'?

To find specific justifications for introducing an energy savings obligation, one must examine market failures other than energy-use externalities that may still lead to an inefficiently high level of energy use. It has long been argued that such market failures exist in the markets for energy efficiency, leading to an inefficiently low level of energy efficiency[7], a phenomenon known as the 'energy

[5] The net effect of white certificate obligations on energy price needs not be an increase. It results from downward forces (lower energy demand) and upward ones (subsidy cost pass-through), and thus depends on the relative slopes of energy supply and demand curves. For instance, electricity supply curves are likely to be relatively flat, hence a price increase is the most plausible outcome in this market (Sorrell et al., 2009).

[6] For further discussion about the interactions between white certificate obligations and other environmental policy instruments, see Child et al. (2008), Sorrell et al. (2009a) and Meran and Wittmann (2012).

[7] This is equivalent to an inefficiently high level of energy use, under the plausible assumption that the rebound effect is less than 100%. See Sorrell et al. (2009b) for a meta-analysis of empirical estimates of the rebound effect.

efficiency gap' (Jaffe and Stavins, 1994). These market failures include (to name only those that proved relevant in the analysis[8]):

- Information problems: Energy efficiency performance is technologically complex and thus partly unobservable. Solutions to these problems include energy labels, energy performance certificates or energy audits.

- Principal-agent problems: The performance of energy efficient technologies is influenced by hidden actions from either the seller (e.g. installation defects) or the buyer (e.g. change in technology utilization). These problems can be solved by professional certification or energy performance contracts (Giraudet and Houde, 2013).

- Credit constraints: Some energy end-users cannot borrow money to invest in energy efficiency, as some investments like home energy retrofits cannot be collateralized. Solutions to this problem include loan facilities (Palmer et al., 2012).

- Inefficient organization in energy efficiency industries: Energy efficiency performance requires complex coordination of multiple technologies (e.g. building envelope and HVAC systems). Firms in each of these technological segments are typically small and numerous (Lutzenhiser, 1994). Some economies of scale and scope may be untapped, making the cost of delivering energy efficiency inefficiently high. This can be solved by horizontal and vertical integration and professional education and training.

- Technology adoption spill-overs: Energy efficient technologies are for the most part already available. Yet technology diffusion needs early adopters to take up (Jaffe et al., 2005). This can be stimulated by temporary subsidies for technology adoption.

The search for cost-effective ways to deliver energy savings should naturally force obligated parties to identify and find solutions to these market failures. The obligation to reduce energy output also forces them to act on their customer's or contractor's premises, rather than on their own. While they have a good knowledge of the latter, it is much less the case with the former. Therefore, the instrument involves a great deal of learning, which should result in innovative organizations, contracts or financing. Note that success in this task is contingent upon a proper measurement and verification system that guarantees property rights on energy savings.

[8] For a broader view of the market and behavioural failures responsible for the energy efficiency gap, see Sorrell et al. (2004), Gillingham et al. (2009) and Allcott and Greenstone (2012).

Lastly, if addressing energy efficiency market failures is to be the main justification of white certificate obligations, then again, the target should not be labelled in energy savings but rather in energy efficiency terms (e.g. an annual number of certified installations of energy efficiency durables to complete).

2.3 How much market to expect?

The trading of energy savings has been emphasized by policy-makers during the implementation process as a positive counterpart to the obligation. This created speculation about the volume of trade that would occur (Langniss and Praetorius, 2004). *A priori*, several factors may influence the volume of trade.

First, trade is empirically low when the target is low. This is well-documented for the early years of the U.S. SO_2 Emissions Trading Program (Burtraw, 1996). If compliance costs are low, obligated parties may prefer to forgo profitable trade opportunities to preserve market shares or avoid passing on strategic information to competitors. Second, for trade to arise, compliance costs must be heterogeneous (Newell and Stavins, 2003). Obligated parties, who have to intervene on their customers' premises rather than on their own, may face heterogeneous consumers. However, such heterogeneity vanishes in the realistic situation where they all have large customer portfolios. Third, under a baseline-and-credit system, credits can be made available for sale only once the target is met. Hence, by construction, the market is likely to be illiquid at the beginning, due to credit supply shortage.

Based on these elements, one would predict low volumes of trade in the early stages of white certificate obligations.

3 Second evaluation phase: *ex post* assessments of static efficiency

The second evaluation phase started when the first stages of each national experience were completed. *Ex post* evaluations then examined the static efficiency performance of the instrument, that is, whether it delivers net social benefits at the lowest possible cost. These assessments involved researchers as well as public bodies.

3.1 Energy savings certificates trading

Examining trading activity, in particular the price of white certificates is a natural first step into assessing the cost-effectiveness of the obligations. In Great Britain, white certificate exchanges have

been negligible[9]. In France, they represented only 4% of certified energy savings. Certificates were traded at an average price of 4c€/kWh. In Italy, trade was involved in 75% of white certificates issuance (Mundaca *et al.*, 2008; Eyre *et al.*, 2009).

Two factors could explain the much contrasted activity in France and Great Britain as compared to Italy. One is the nature of the obligated party. In France and Great Britain, obligations are placed on energy suppliers. This situation favours direct action. In Italy, obligations are imposed on energy distributors, who are more remote from end-users. This situation favours the purchase of white certificates generated by other agents. Another factor is the organisation of a trading platform, which exists in Italy and, to a lesser extent, in France. The similarity of French and British outcomes relative to the Italian experience suggests that the first factor may have greater power than the second to explain market activity[10].

In Italy, the distance between energy distribution and end-users has led obligated distributors to outsource energy efficiency measures by purchasing white certificates from third parties at an average market price of €60/toe (Giraudet and Finon, 2011, figure 1). At the same time, they were granted €100 for every toe of certified savings by the regulator to cover the costs induced by the obligation. This led to large private benefits[11].

Besides considerations on the type of actor involved, other factors explain the absence of white certificate exchanges – and thus of horizontal transactions – in France and in Great Britain. Early analysis suggests that cost heterogeneity among obligated parties, which is the condition for horizontal transactions, is low in these countries (Mundaca, 2007; Giraudet *et al.*, 2012). In this context,

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[9] Small amounts of energy savings from the "Warm Front" program, a public fund targeted to alleviate fuel poverty, have been purchased by some obligated parties to meet their obligation in 2002-05 (Mundaca *et al.*, 2008).

[10] The French *Cour des comptes*, which conducts financial and legislative edits, expressed concerns that the way prices are formed on the French trading platform lacks transparency (Cour des comptes, 2013).

[11] The regulator intervened in white certificates markets by increasing the number of obligated parties and unifying the electricity and gas certificates to reduce the concentration of market players. The market reacted by increasing the average exchange price, thus lowering the benefits accruing to distributors and keeping the incentives for energy service companies to invest in costlier measures high. Moreover, the tariff contribution has been decreased to 80€/toe.

obligated suppliers show preference towards autarkic strategies, as some commercial benefits might arise from non-trading.

Overall, transactions *among obligated parties* have been scarce everywhere, which is consistent with theoretical predictions. White certificate prices can therefore not be used as a reliable proxy for cost-effectiveness; a broader examination is needed.

Table 1: Transactions in white certificate obligations

	Great Britain 2005-08	Italy 2005-08	France 2006-09
Transactions between obligated parties and other energy companies (obligated or eligible)	Vertical transactions, no trade	Vertical transactions prevail (75%), mainly through spot and over-the-counter markets	Vertical transactions, very little over-the-counter trade (4%)
Transactions between obligated parties and energy end-users	Financial incentives for the purchase of energy efficient equipment	Reduction coupons, information	Information and advice, advertising for tax credits, some financial incentives

3.2 Social benefit-cost assessments

Benefit-cost assessments were conducted by Lees (2008) for the 2005-2008 period in Great Britain[12], Giraudet et al. (2012) for the 2006-2009 period in France and Mebane and Piccinno (2012) for the 2005-2010 period in Italy. These analyses used comparable methodologies. For an extensive discussion of the methodological issues involved, see Giraudet et al. (2012).

[12] The 2002-05 period has been evaluated by Lees (2005), Mundaca (2007) and Mundaca and Neij (2009).

3.2.1 Energy savings effectiveness

The data readily available to assess the effectiveness of energy savings is the number of measures completed and the standardized energy savings calculations attached to each[13]. In France and Great Britain, the average lifetime of energy saving measures was 20-30 years; in Italy, it was only two years. Savings are discounted at close rates of 3.5% in Great Britain, 4% in France and 4.4% in Italy.

Standardized calculations may overestimate real energy savings, as they do not account for the following elements:

- Additionnality: Some customers of obligated parties may receive free services they would have been willing to purchase anyway[14].
- The rebound effect: Consumers may respond to energy efficiency investments by increasing comfort (e.g. setting heating thermostat to a higher temperature). Although empirically established (Sorrell et al., 2009b), this response is so heterogeneous across consumers that it is generally not accounted for in standardized calculations.
- Issues with technology installation: If improperly installed, technologies such as insulation or efficient HVAC underperform engineering projections. Such defects are very costly to monitor. In other situations, such as CFLs, there is no control over whether or not consumers install at all the devices they are given.
- Distorted calculations: In Great Britain, 'uplift factors' are applied to standardized calculations to specifically encourage some measures considered as innovative, such as digital TVs. In France, education of professionals can be claimed by obligated parties to acquire white certificates, without any quantification of the energy savings induced[15].

[13] In all countries, non-standardized measures requiring specific calculations can be completed. Since they accounted for a negligible share of total energy savings, they are generally not accounted for.

[14] Some authors argue it is not necessarily an issue as some non-additional program participants may also be free-drivers, i.e. early adopters of a technology who trigger market transformation (Blumstein and Harris, 1993).

[15] The number of white certificates created is equal to the total education expenses divided by the maximum price of white certificates, equal to the penalty charged for missing energy savings (0.02€/kWh).

In his evaluation of the British obligation, Lees (2008) removed uplift factors to get a more accurate estimate of energy savings. In France, educational measures were negligible, so calculation distortions could be ignored. Lees discounted his energy savings calculations by 20% to account for non-additional measures and another 15% to account for comfort increase. Since little background was given to motivate these figures, and to ease comparison with other evaluations which did not use such corrections, we report Lees' gross figures in the comparison conducted here. No evaluation addressed the issues with technology installation.

3.2.2 Costs and benefits of energy savings

Evaluating the direct costs of the measures completed is the starting point of all evaluations. Direct measure costs refer to the costs of energy efficiency improvements. This includes the whole capital cost for rationalization investments such as insulation, but only the cost differential with the market standard for replacement investments such as a heating system[16]. In all countries, these costs were estimated from market data.

Obligated parties are assumed to contribute to direct costs by offering financial incentives and other services. The remaining part of energy efficiency investments is borne by customers, with the possible help of other actors, such as social housing providers and managing agents in Great Britain, or the Government, as the funder of an overlapping tax credit scheme in France. Identifying the cost share borne by obligated parties is uneasy. In Great Britain and France, evaluators used both publicly available information (e.g. advertisement) and interviews with obligated parties, who however showed some reluctance to share information (DECC, 2011; Cour des comptes, 2013). In Italy, no specific contribution of obligated parties was estimated.

Next to the direct costs of energy efficiency improvements, obligated parties bear indirect costs generated by tasks such as project development, marketing and reporting. In Great Britain, Lees (2008) estimated from his past experience with evaluating energy efficiency programs indirect costs to be 18% of obligated parties' direct costs. In France, Giraudet et al. (2012, Table 7) based their quantification of indirect costs on interviews with obligated parties. In Italy, obligated parties are granted a cost recovery contribution by public bodies, officially to cover indirect costs. Yet there is no way to ascertain whether the amounts granted by public bodies and reported by Mebane and Piccinno

[16] This calculation rule is explicitly acknowledged in Lees (2008) and Giraudet et al. (2012). It is not explicit in Mebane and Piccinno (2012) but was acknowledged to us by the authors through personal communication.

(2012) were commensurate with the indirect costs effectively borne by obligated parties. Therefore, these costs are reported in Table 2 as 'other party cost' rather than as 'obligated parties' indirect costs'.

Obligated parties' total cost is the sum of the direct costs and indirect costs. In France, this total cost estimate is very consistent with the market price of white certificates. In Italy, we could not identify obligated parties' direct costs so we did not compute their total cost.

Lastly, economic and social benefits in national assessments include fuel bill alleviation and, except in Italy where they were not calculated, CO_2 emission reductions. They are estimated assuming conventional projections for energy prices and national carbon values.

Table 2: Costs and benefits of white certificate obligations in the periods examined

	Great Britain 2005-08	France 2006-09	Italy 2005-10
Program costs			
Obligated party indirect cost (M€)	195	136	n/a
Obligated party direct cost (M€)	1,085	74	3,124
Customer cost (M€)	325	504	
Other party cost (M€)	153	1,305	857
TOTAL COSTS (M€)	1,758	2,019	3,981
Program benefits			
End-use energy savings (TWh)	192	54	97
Monetary value of energy savings (M€)	13,020	4,320	12,378
CO_2 savings ($MtCO_2$)	72.6	20.0	n/a
Central monetary value of CO_2 savings (M€)	7,686	921	-
TOTAL BENEFITS (M€)	20,702	5,241	-
Net social benefits, excluding CO_2 savings (M€)	11,262	2,301	8,397
Net social benefits, including CO_2 savings (M€)	18,948	3,222	-

Cost-efficiency, excluding CO_2 savings (€ gained per € spent)	7.41	2.14	3.11
Cost-efficiency, including CO_2 savings (€ gained per € spent)	11.78	2.60	-
Cost-effectiveness (c€ spent per kWh saved)	0.91	3.7	4.1
Unitary cost for obligated parties (c€ spent per kWh saved)	0.67	0.39	-

Note: Assumptions for the social value of CO_2: For Great Britain official value for policies affecting non-ETS sectors: £52/tCO_2 in 2010, £60/tCO_2 in 2020, £70/tCO_2 in 2030 (DECC, 2010, Table 1); for France official value set by Quinet et al. (2008): 32€/tCO_2 in 2010, 56€/tCO_2 in 2020 and 100€/tCO_2 in 2030.

Source: Lees (2008), Giraudet et al. (2012), Mebane and Piccino (2012)

The total cost per kWh saved was 0.91 c€ in Great Britain, 3.7c€ in France and 4.1c€ in Italy (Table 2). These estimates are below energy prices in all countries, even up to ten times lower in Great Britain. Benefit-cost balances (excluding CO_2 savings) were overwhelmingly positive, with €11 billion in Great Britain, €8 billion in Italy and €2 billion in France. However, benefit-cost balances show large discrepancies across countries, which motivates a close examination of the technical and institutional determinants of energy saving measures patterns in each country.

3.2.3 Determinants of static efficiency

In every country, over the periods examined, most energy savings came from one dominant measure: insulation in Great Britain (75%), compact fluorescent light bulbs (CFLs) in Italy (54%), and heating device replacements in France (68%). Flexibility of the obligations should have attracted obligated parties towards insulation measures, identified as the deepest and most cost-effective potential for energy efficiency improvements in developed countries by a number of bottom-up studies (Ürge-Vorsatz and Navikova, 2008). The gap between this expectation and effective realisations can be explained by differences in national infrastructures. Regarding insulation, the cavity wall insulation (CWI) technique, inherent to the British building stock, dominates in Great Britain, while solid wall insulation (SWI) is the only technique to be implemented in France because of different construction techniques. The former generates energy savings at a cost per dwelling around ten times lower than the latter (Eyre *et al.*, 2009; Giraudet *et al.*, 2012). Accordingly, British energy suppliers have intensely harvested the potential for cavity wall measures, which represented 56% of the kWh saved in 2002-05

and 75% in 2005-08 (Lees, 2008). This is the most plausible explanation for the high cost-effectiveness of the British obligation.

Albeit costlier than in Great Britain, insulation offers the biggest potential for energy savings in France. The fact that it represents less than 10% of achieved energy savings seriously erodes the cost-effectiveness of the obligation, compared to its British counterpart (Giraudet and Finon, 2011, table 5). Unlike cavity wall insulation, solid wall insulation does not lend itself to large-scale standardized measures. In Italy, there is an additional explanation: The short lifespan used to calculate deemed savings (set to five years; now eight years for insulation) does not provide an adequate incentive for long-term saving measures. This value remains far below those used in Great Britain and France (40 and 35 years, respectively), and insulation is notably absent in Italy.

3.2.4 Obligated parties' revenue-cost balance

The discrepancy between Great Britain and France is reversed when it comes to the burden of obligated parties. Whereas British energy suppliers bear 73% of total costs for a unitary cost of 0.67 c€ per kWh saved, the French major suppliers bear only 10% of total costs for a unitary cost of 0.39 c€ per kWh saved (see Table 2). This reveals an uneven propensity of the parties to both undertake costly energy efficiency measures and to actively incentivize them.

In Great Britain, subsidizing energy efficiency measures is the main delivery route followed by energy suppliers. In parallel, the absence of any energy price regulation enables them to pass-through the compliance cost onto their energy retail price. Subsidizing is also a means of commercial differentiation in the British competitive retail markets. Lees (2008) estimates energy suppliers' expenditure to represent, on average, €9.7 per customer per year; if fully passed-through, this amount is equivalent to an increase of 1-2% in the average fuel bill. To our knowledge, no econometric analysis was conducted to identify any causal effect of the obligation on energy prices.

In France, in electricity and natural gas markets, regulated tariffs of former state monopolies persist, at a rate lower than the wholesale price. There is no legal provision to pass through the cost of energy saving obligations onto these tariffs. In this context, historic suppliers manage to comply with their obligation by offering relatively inexpensive energy efficiency services, such as technical and financial advice. Indeed, they take advantage of the tax credit scheme to induce consumers to invest in efficient electricity and gas heating devices. The ten most granted measures all benefited from tax credit rates ranging from 15 to 50% of investment cost over the 2006-09 period (Giraudet and Finon, 2011, table 5). This policy overlap has stimulated the penetration of heat pumps and condensing boilers (Bodineau and Bodiguel, 2009). These technologies are closely related to the core business of energy suppliers and in collaboration with their traditional partners such as installers of heating devices, the tax credits

were advertised to convince consumers. Much less has been done on insulation measures, where tax credits did not cover the substantial installation costs.

The *Commission de regulation de l'énergie*, the regulator of electricity and natural gas markets has exclusive access to accounting data of EDF, France's biggest electricity suppliers. This allowed the institution to assess that the white certificate obligation represented 16% of the company's commercial cost in 2012, which in turn represented 8.8% of the company's total costs that year (CRE, 2013). Overall, the obligation represented 1.4% of EDF's total cost. The regulator estimated the obligation to be responsible for moderate increases of 1% for electricity tariffs and 0.5% for natural gas tariffs.

In contrast, on the fuel oil segment, we observe a situation similar to that of Great Britain: Prices are not regulated and fuel oil suppliers grant subsidies to households for efficient boilers[17].

In Italy, over the period examined, a peculiar situation has prevailed whereby obligated distributors were granted €100 for every toe of certified savings while purchasing white certificates at an average market price of €60/toe (see above). Energy distributors have promoted 'low hanging fruits' such as CFLs and hot water economizers, merely by distributing reduction coupons which might not necessarily lead to equipment purchase. This regulatory pitfall was corrected in 2008 and the tariff contribution was lowered to 80€/toe. Contrary to France, there was no interaction with the tax credit scheme, which targeted larger investments (Mebane et Piccino, 2012)

To summarize, a common trend emerges from the comparison of the three country's experiences: Targets are fulfilled at levels of cost-effectiveness and efficiency that are favourable yet not necessarily optimal from a social viewpoint. The measures implemented are not necessarily the cheapest for customers, but the most rewarding for obligated parties, given the incentive structures created by the institutional environment. Obligated party strategies towards final consumers do not rely exclusively on subsidization and are correlated with the cost recovery possibilities offered by the energy price regulation rules. Whether obligated parties recover the full cost of their obligations through increased energy revenue remains an open question.

[17] Such behaviour is also motivated by the need to keep incentives high to counteract the decline of fuel oil use with growing environmental concerns. Interestingly, although not obligated at the beginning of the consultation process, fuel oil retailers saw an opportunity to safeguard their businesses and asked to participate in the obligation.

4 Third evaluation phase: *ex post* assessments of dynamic efficiency

In parallel to gross quantification of static efficiency, some works have examined the dynamic efficiency of white certificate obligations, that is, the extent to which they help overcome market failures in energy efficiency markets. This section reviews qualitative surveys conducted for the most recent periods of the British (2008-2011) and French (2011-2013) obligations (Ipsos MORI et al., 2011; ADEME, 2013)[18]. To our knowledge, no such surveys were conducted in Italy.

4.1 Market transformation

Transforming the markets for energy efficiency is an explicit goal of white certificate obligations. In Great Britain, significant market transformation has been observed: The adoption of CFLs and efficient appliances (A-rated wet and cold appliances) has been widespread, the market for condensing boilers has reached full maturity and a sizeable share of the housing stock that lends itself to cavity wall insulation has been treated (Lees, 2008). The evaluator attributes this change to the white certificate obligation with a high level of confidence. The suspicion of a causal relationship is reinforced by the fact that the markets for integrated digital televisions and stand-by savers, the deemed savings of which benefited from a 20% uplift factor, have been completely transformed in a very short period of time. Yet more complex technological measures such as solid wall insulation or whole house retrofits have not taken up (DECC, 2011).

In Italy, water economizers and CFLs have diffused widely (Mebane and Piccinno, 2012). In France, no substantial shift in the market shares of the main eligible technologies has been observed. The price index of construction has been relatively stable there, which suggests that the instrument had no effect on technology prices (Cour des comptes, 2013). In both countries, the specific effect of the obligation on market transformation is difficult to separate from the one of overlapping tax credits.

[18] The British survey consisted in 65 in-depth interviews with key stakeholders, and a research with householders, comprising a nationally representative face-to-face survey (1,613 households), and face-to-face in-depth interviews with 47 householders who had taken up measures and 30 who had not (Ipsos MORI et al., 2011). The French survey consisted in phone interviews and internet questionnaires involving 4,466 householders who had all taken up measures (ADEME, 2013). The latter survey did not involve any control group, which may lead to overestimate the performance of the obligation.

Overall, no causal relationship of white certificate obligations on market transformation was formally tested in any country. Even if causality held, the measures the obligations have contributed to deliver are generally considered low hanging fruits.

4.2 Financial incentives

In Great Britain, it is generally assumed that all measures were delivered through direct subsidies. The qualitative survey revealed that the subsidies were spread across all income groups, although they preferentially reached owner-occupiers, living in semi-detached houses (rather than flats), in urban and suburban areas (rather than metropolitan and remote rural areas). Subsidies seem to have been decisive: Saving money was the main motivation for 79% of householders who had installed insulation; in turn, 'too high upfront costs' were the main reason for not investing claimed by around 20% of those who had not invested (Ipsos MORI et al., 2011, fig. 11 & 14). There are some concerns among stakeholders that insulation in Great Britain is now highly dependent on subsidy, which can have perverse consequences.

In France, financial incentives were important but most likely not involved in all measures. Of all financial incentives estimated by Giraudet et al. (2012), two-thirds were direct subsidies and one-third was reduced interest rate loans. More than 75% of survey respondents considered that financial incentives were decisive along several margins: They helped them invest more quickly (30-40% of respondents), choose higher efficiency levels (30-50%) and rely more on professional installation (50-60%). For more than a half of respondents, white certificate subsidies were the only financial incentive received[19]. Saving money was the main motivation for more than 60% of householders.

Theoretically, the two types of incentives offered by obligated parties address different types of market failures: technology adoption spill-overs for direct subsidies, credit constraints for reduced interest rate loans. Whether each incentive has met its specific goal was not empirically tested.

4.3 Quality assurance

One market failure potentially affecting energy efficiency investments is the moral hazard caused by the unobservable characteristic of the quality offered by installers of energy efficient technologies (Giraudet and Houde, 2013). From the surveys conducted, there is little reason to believe that white certificate obligations helped address this market failure.

[19] In their benefit-cost assessment, Giraudet et al. (2012) assumed this share to be zero percent, that is, full overlap between the two instruments.

In Great Britain, around 30% of insulation jobs were 'do-it-yourself' installations, offering virtually no quality assurance. Moreover, stakeholders reported to OFGEM that 15% of the jobs suffered from technical failures. Lastly, DECC used the National Energy Efficiency Data-framework to do some comparisons of household natural gas use before and after the installation of energy efficiency measures, compared to a control group where no measures were installed. This analysis revealed that energy savings from cavity wall insulation have been lower than expected, without any possibility to attribute this shortfall to behavioural change or quality issues (NEED, 2011). The survey also provided evidence that such potential defects affect the trust consumers have in energy efficiency: When asked what would encourage them to install energy efficiency measures, 21% responded 'Evidence that it would save money on bills', 13% responded 'Evidence I would notice savings on bills soon' and 4% responded 'Knowing a trustworthy installer' (Ipsos et al., 2011, Fig. 16). Half of householders who installed measures claim it reduced their energy bill, although only a few know it for certain.

In France, no quantitative estimate exists to assess this point. Standardized measures must be installed by professionals, but as of today, no certification is required (except for a few measures like solar water heaters and heat pumps). This will change in the future, as white certificate obligations, like other financial incentives such as tax credits and zero interest rate loans, will be subject to 'eco-conditionnality': Measures will have to be installed by certified professionals to be counted against the obligation target (MEDDE, 2013). The survey reported that satisfaction after investment is high, as 95% of respondents believe that their energy bill has been reduced (but only 33% have effectively observed it).

4.4 Information provisions

In Great Britain, the survey revealed that the lack of awareness of energy saving opportunities was the main reason why some householders declared they had not installed insulation (Ispos et al., 2011, Fig.14). This was especially true for cavity wall insulation. This confirms the existence of an information gap in Great Britain and builds confidence in the ability of white certificate obligations to address it. The main information channels in Great Britain were mail-outs and door knocking.

In France, information disclosure was an important delivery route followed by obligated parties, in particular on the electricity segment. It relied essentially on phoning and free energy audits. In the survey conducted by ADEME, 35 to 75% of householders who benefited from measures declared that information and advice they received was decisive to motivate their decision to install more energy efficient technologies than initially planned. The wide dispersion of these estimates and the absence of a control group in the survey may overestimate this figure.

4.5 Organisational change

Energy efficiency businesses, in particular the insulation industry, involve a large number of small actors. The need for obligated parties to operate at a large scale may lead them to engage these actors and provide them with professional education, training and labeling. The resulting economies of scale and scope may ultimately materialize as lower costs of energy efficiency. In every country, obligated parties have build long-term vertical, mutually benefiting relationships with related businesses: Obligated parties rely on installers to convey information and ultimately act towards end-users, while installers access the large customer portfolio of energy suppliers.

In Great Britain, energy suppliers have developed close relationships with insulation contractors, managing agents, housing promoters, retailers and manufacturers, and have developed partnerships with social housing programs and charity organisations. For instance, insulation measures have been subcontracted to a handful of actors that dominate the insulation market. This implies a very competitive bidding process that equalized compliance costs among obligated suppliers (Eyre *et al.*, 2009; Lees, 2008; Mundaca *et al.*, 2008). For measures involving uplift factors, energy suppliers have dealt directly with product manufacturers to accelerate economies of scale. According to energy suppliers, economies of scale have decreased the price of energy efficient technologies (DECC, 2011, p.29).

In France, all energy efficiency actions of major energy suppliers have been operated by heating device installers. Obligated suppliers have focused on educating installers in order to put more structure and skills in the field.

In Italy, as noted, the distance between energy distributors and end-users implies vertical transactions as well. These transactions are based on white certificate exchanges outside of the organised market. The obligation was supposed to serve the development of energy service companies that fill the gap between distributors and end-users. So far, this objective has been met only partially, as energy service companies that develop skills in energy efficiency projects independently from obligated parties are rare. Rather, many of them are small subsidiaries of obligated distributors, sometimes created with the only purpose to distribute reduction coupons on CFLs to consumers.

5 Conclusions

White certificate obligations impose energy saving targets on energy companies and allow them to trade energy savings certificates. Though simple, this principle is non-trivial. From a public economics perspective, it can be rationalized in different ways. On the one hand, the obligation can be seen as a means of internalizing externalities associated with energy use. In this view, how does the instrument

compare to other well-known solutions to this problem, such as taxes, subsidies or regulations? On the other hand, the instrument can be seen as a solution to the market failures at the source of the 'energy efficiency gap'. Yet how can one instrument address several market failures at a time? Overall, the instrument relies on market mechanisms but embodies a stringent command-and-control component, as energy companies are forced to reduce their output. This lack of a clear, unique view of the instrument makes it difficult to empirically investigate whether it meets its objectives.

In this paper, we reviewed existing evaluations of the British, Italian and French experiences with white certificate obligations. Our goal was to better grasp the nature of the instrument and assess its performance in real world contexts.

We found that theoretically, white certificate obligations are best modelled as hybrid subsidy-tax instruments. According to this representation, reducing energy use generates expenditures that are passed-through onto energy prices. This characteristic may make white certificate obligations politically more acceptable than energy taxes, but raises equity concerns if some consumers do not receive subsidies they however contributed to pay for. In real world situations, we found that energy efficiency-inducing expenditures consist mainly in subsidies. Energy companies also respond to white certificate obligations by conveying information about energy saving opportunities. They also work with energy efficiency businesses (manufacturers, installers, etc.) to generate economies and deliver energy savings more efficiently. This suggests that white certificate obligations help internalize energy-use externalities and address information gaps, organisational inefficiencies and liquidity constraints that hamper energy efficiency investments. In contrast, they do little to address quality assurance and even less to address landlord-tenant split incentives, a market failure commonly cited as an important source of the energy efficiency gap.

Existing evaluations of white certificate obligations find largely positive benefit-cost balances in all countries. Differences in cost-effectiveness across countries mainly reflect heterogeneity in technical potentials. Obligated parties did not rely much on white certificate exchanges with other obligated parties to meet their target, which is consistent with theoretical predictions based on the 'baseline-and-credit' nature of the instrument. Whether the costs of the national obligations are passed-through onto energy prices could not be ascertained. Yet cost-recovery rules seem to have influenced delivery routes, with higher levels of subsidization correlated with less regulation of energy prices.

One major lesson of this review is that existing evaluations of white certificate obligations do not yet meet the empirical standards generally applied in public policy evaluation. None of the works reviewed used econometric analysis, neither within nor across countries. This is in contrast with U.S. demand-side management programs, which have a similar rationale, and the econometric evaluation of

which started early on (see Gilligham et al., 2006, for a review). It is also in contrast with overlapping instruments, such as tax credits in France, which have been evaluated through multiple approaches, using different data sets (Mauroux, 2012; Nauleau, 2013). Several reasons may explain this gap. First, white certificate obligations are still recent. More distance is needed to collect data and perform econometric analysis. Second and more importantly, contrary to its counterparts mentioned above, the rationale of the instrument of harnessing private financing does not facilitate information disclosure. As obligated parties show reluctance to share information about costs or delivery routes, virtually no information is available beyond what is required by administrators of the obligations, which is limited to the list of measures completed. Still, publicly available market data could be used to assess econometrically the causal effect of white certificate obligations on market transformation.

Lastly, one area that deserves more analysis is the political economy of the instrument. In countries where energy prices are regulated, obligated parties show strong opposition to the obligation, as they cannot recoup its cost. This implies intense lobbying either for making poorly additional measures eligible or against setting ambitious energy saving targets. In France, the Cour des comptes (2013), which conducts legislative and financial audits of public institutions, reports that obligated parties succeeded in having the Administrator maintain the eligibility of low-temperature boilers, a poorly additional measure that was yet banned from the tax credit scheme. This is a fruitful area for both theoretical and empirical research.

Acknowledgements

We thank the two anonymous referees, Mark Jaccard, Franck Lecocq,William Mebane, Emanuele Piccinno and Philippe Quirion for their feedback and helpful comments.

References

ADEME, [Agence de l'environnement et de la maîtrise de l'énergie], 2013. Evaluation qualitative du dispositif CEE 2ème période 2011-2013.

AEEG, [Autorità per l'energia elettrica e il gas], 2008. Terzo rapporto annuale sul mecanismo dei titoli di efficienza energetica.

Allcott, H., Greenstone, M., 2012. Is There an Energy Efficiency Gap? Journal of Economic Perspectives 26, 3–28. doi:10.1257/jep.26.1.3

Bertoldi, P., Rezessy, S., 2008. Tradable white certificate schemes: fundamental concepts. Energy Efficiency 1, 237–255. doi:10.1007/s12053-008-9021-y

Bertoldi, P., Rezessy, S., Lees, E., Baudry, P., Jeandel, A., Labanca, N., 2010. Energy supplier obligations and white certificate schemes: Comparative analysis of experiences in the European Union. Energy Policy 38, 1455–1469. doi:10.1016/j.enpol.2009.11.027

Blumstein, C., Harris, J.P., n.d. The cost of energy efficiency. Science 261, 970.

Bodineau, L., Bodiguel, A., 2009. Energy Savings Certificates (ESC) scheme in France: initial results, in: Proceedings of the ECEEE 2009 Summer Study.

Burtraw, D., 1996. The so2 Emissions Trading Program: Cost Savings Without Allowance Trades. Contemporary Economic Policy 14, 79–94. doi:10.1111/j.1465-7287.1996.tb00615.x

Bye, T., Bruvoll, A., 2008. Multiple instruments to change energy behaviour: The emperor's new clothes? Energy Efficiency 1, 373–386. doi:10.1007/s12053-008-9023-9

Child, R., Langniss, O., Klink, J., Gaudioso, D., 2008. Interactions of white certificates with other policy instruments in Europe. Energy Efficiency 1, 283–295. doi:10.1007/s12053-008-9025-7

Cour des comptes, 2013. Les certificats d'économies d'énergie. Communication au premier ministre.

CRE, [Commission de régulation de l'énergie], 2013. Analyse des coûts de production et de commercialisation d'EDF dans le cadre des tarifs réglementés de vente d'électricité.

DECC, [Department of Energy and Climate Change], 2010. Carbon Appraisal in UK Policy Appraisal: A revised Approach.

DECC, [Department of Energy and Climate Change], 2011. RESEARCH REPORT. Evaluation synthesis of energy supplier obligation policies.

DGEC, [Direction générale de l'énergie et du climat], 2009. Lettre d'information certificats d'économies d'énergie, juillet.

Eyre, N., Pavan, M., Bodineau, L., 2009. Energy company obligations to save energy in Italy, the UK and France: what have we learnt?, in: Proceedings of the ECEEE 2009 Summer Study.

Gillingham, K., Newell, R., Palmer, K., 2006. Energy Efficiency Policies: A Retrospective Examination. Annual Review of Environment and Resources 31, 161–192. doi:10.1146/annurev.energy.31.020105.100157

Gillingham, K.T., Newell, R.G., Palmer, K., 2009. Energy Efficiency Economics and Policy. Annual Review of Resource Economics 1, 597–620.

Giraudet, L.-G., Bodineau, L., Finon, D., 2011. The costs and benefits of white certificates schemes. Energy Efficiency 5, 179–199. doi:10.1007/s12053-011-9134-6

Giraudet, L.-G., Finon, D., 2011. White certificates schemes: the static and dynamic efficiency of an adaptive policy instrument. CIRED working paper 33-2011. http://www.centre-cired.fr/spip.php?article1302&lang=en

Giraudet, L.-G., Houde, S., 2013. Double moral hazard and the energy efficiency gap. IAEE Energy Forum. http://www.iaee.org/en/publications/newsletterdl.aspx?id=188

Giraudet, L.-G., Quirion, P., 2008. Efficiency and distributional impacts of tradable white certificates compared to taxes, subsidies and regulations. Revue d'économie politique 118, 885–914.
IEA, [International Energy Agency], AFD, [Agence française de développement], 2008. Promoting energy efficiency investments. Case studies in the residential sector. OECD, Paris.
Ispos MORI, CAG consultants, BRE, 2011. Evaluation of the delivery and uptake of the Carbon Emissions Reduction Target (Research Report to DECC).
Jaffe, A.B., Newell, R.G., Stavins, R.N., 2005. A tale of two market failures: Technology and environmental policy. Ecological Economics 54, 164–174. doi:10.1016/j.ecolecon.2004.12.027
Jaffe, A.B., Stavins, R.N., 1994. The energy-efficiency gap What does it mean? Energy Policy 22, 804–810. doi:10.1016/0301-4215(94)90138-4
Langniss, O., Praetorius, B., 2006. How much market do market-based instruments create? An analysis for the case of "white" certificates. Energy Policy 34, 200–211. doi:10.1016/j.enpol.2004.08.025
Lees, E., 2005. Evaluation of the Energy Efficiency Commitment 2002-05, Report to DEFRA.
Lees, E., 2008. Evaluation of the Energy Efficiency Commitment 2005-08, Report to DECC.
Lutzenhiser, L., 1994. Innovation and organizational networks Barriers to energy efficiency in the US housing industry. Energy Policy 22, 867–876. doi:10.1016/0301-4215(94)90146-5
Mauroux, A., 2012. Le crédit d'impôt dédié au développement durable : une évaluation économétrique. Série des documents de travail de la Direction des Études et Synthèses Économiques, INSEE.
Mebane, W., Piccinno, E., 2012. Economic analysis of energy efficiency programs in Italy. Energia, Ambiente e Innovazione, Review & Assessment Papers.
MEDDE, [Ministère de l'écologie, du développement durable et de l'énergie], 2013. Dispositif des certificats d'économies l'énergie. Mise en oeuvre de la troisième période (2015-2017).
Meran, G., Wittmann, N., 2012. Green, Brown, and Now White Certificates: Are Three One Too Many? A Micro-Model of Market Interaction. Environmental and Resource Economics 53, 507–532. doi:10.1007/s10640-012-9574-2
Mundaca, L., 2007. Transaction costs of Tradable White Certificate schemes: The Energy Efficiency Commitment as case study. Energy Policy 35, 4340–4354. doi:10.1016/j.enpol.2007.02.029
Mundaca, L., Neij, L., 2009. A multi-criteria evaluation framework for tradable white certificate schemes. Energy Policy 37, 4557–4573. doi:10.1016/j.enpol.2009.06.011
Mundaca, L., Neij, L., Labanca, N., Duplessis, B., Pagliano, L., 2008. Market behaviour and the to-trade-or-not-to-trade dilemma in "tradable white certificate" schemes. Energy Efficiency 1, 323–347. doi:10.1007/s12053-008-9026-6
Nauleau, M.-L., 2013. Heavy subsidization reduces free-ridership: Evidence from an econometric study of the French dwelling insulation tax credit. CIRED Working Paper.
NEED, [National Energy Efficiency Data-Framework], 2011. Report on the development of the data-framework and initial analysis. DECC.
Newell, R.G., Stavins, R.N., 2003. Cost Heterogeneity and the Potential Savings from Market-Based Policies. Journal of Regulatory Economics 23, 43–59. doi:10.1023/A:1021879330491
Oikonomou, V., Jepma, C., Becchis, F., Russolillo, D., 2008. White Certificates for energy efficiency improvement with energy taxes: A theoretical economic model. Energy Economics 30, 3044–3062. doi:10.1016/j.eneco.2008.04.005
Palmer, K., Walls, M., Gerarden, T., 2012. Borrowing to Save Energy: An Assessment of Energy-Efficiency Financing Programs. Resources for the Future Discussion Paper.

Pavan, M., 2008. Tradable energy efficiency certificates: the Italian experience. Energy Efficiency 1, 257–266. doi:10.1007/s12053-008-9022-x
Perrels, A., 2008. Market imperfections and economic efficiency of white certificate systems. Energy Efficiency 1, 349–371. doi:10.1007/s12053-008-9020-z
Quinet, A., Baumstark, L., Célestin-Urbain, J., Pouliquen, H., Auverlot, D., Raynard, C., 2008. La valeur tutélaire du carbone. Rapport de la commission présidée par Alain Quinet, Conseil d'Analyse Stratégique. La documentation française, Paris.
Radov, D., Klevnas, P., Sorrell, S., 2006. Energy efficiency and trading. Part I: Options for increased trading in the energy efficiency commitment, Report to Defra.
Sorrell, S., 2004. Understanding barriers to energy efficiency, in: The Economics of Energy Efficiency: Barriers to Cost-Effective Investment. Edward Elgar, Cheltenham.
Sorrell, S., Dimitropoulos, J., Sommerville, M., 2009a. Empirical estimates of the direct rebound effect: A review. Energy Policy 37, 1356–1371. doi:10.1016/j.enpol.2008.11.026
Sorrell, S., Harrison, D., Radov, D., Klevnas, P., Foss, A., 2009b. White certificate schemes: Economic analysis and interactions with the EU ETS. Energy Policy 37, 29–42. doi:10.1016/j.enpol.2008.08.009
Taylor, M.R., Rubin, E.S., Hounshell, D.A., 2005. Regulation as the Mother of Innovation: The Case of SO2 Control*. Law & Policy 27, 348–378. doi:10.1111/j.1467-9930.2005.00203.x
Tinbergen, J., 1952. On the theory of economic policy, North Holland. ed. Amsterdam.
Ürge-Vorsatz, D., Novikova, A., 2008. Potentials and costs of carbon dioxide mitigation in the world's buildings. Energy Policy 36, 642–661. doi:10.1016/j.enpol.2007.10.009